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A

DICTIONARY

OF

ARTS, MANUFACTURES,

AND

MINES;

CONTAINING

A CLEAR EXPOSITION OF THEIR PRINCIPLES AND PRACTICE.

BY

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ILLUSTRATED WITH TWELVE HUNDRED AND FORTY ENGRAVINGS ON WOOD.

IN TWO VOLUMES.

VOL. I.

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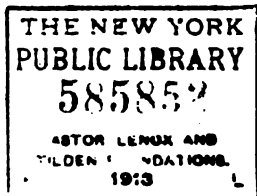
PREFACE.

It is the business of operative industry to produce, transform, and dis-
tribute all such material objects as are suited to satisfy the wants of man-
kind. The primary production of these objects is assigned to the husband-
man, the fisherman, and the miner; their transformation to the manufacturer
and artisan; and their distribution to the engineer, shipwright, and sailor.[*]
The unworked or raw materials are derived,—1. from the organic processes
of vegetables and animals, conducted either without or with the fostering
care of man; 2. from the boundless stores of mineral and metallic wealth,
arranged upon or within the surface of the earth by the benignant Parent
of our being, in the fittest condition to exercise our physical and intellectual
powers in turning them to the uses of life.

The task which I have undertaken in the present work, is to describe
and explain the transformations of these primary materials, by mechanical
and chemical agencies, into general objects of exchangeable value; leav-
ing, on the one hand, to the mechanical engineer, that of investigating the
motive powers of transformation and transport; and, on the other hand, to
the handicraftsman, that of tracing their modifications into objects of special
or local demand. Contemplated in this view, an art or manufacture may
be defined to be that species of industry which effects a certain change in
a substance, to suit it for the general market, by combining its parts in a
new order and form, through mechanical or chemical means. Iron will
serve the purpose of illustrating the nature of the distinctions here laid
down, between mechanical engineering; arts and manufactures; and handi-
craft trades. The engineer perforates the ground with a shaft, or a drift,
to the level of the ore, erects the pumps for drainage, the ventilating, and
hoisting apparatus, along with the requisite steam or water power; he con-
structs the roads, the bridges, canals, railways, harbors, docks, cranes, &c.,
subservient to the transport of the ore and metal; he mounts the steam or
water-power, and bellows for working the blast-furnaces, the forges, and
the cupolas; his principal end and aim on all occasions being to overcome
he forces of inertia, gravity, and cohesion. The ores extracted and sorted

*For correct and copious information upon *agricultural* production, I have great
pleasure in referring my readers to Mr. Loudon's elaborate *Encyclopedias of Agriculture,
Gardening, and Plants;* and for *mercantile* production and distribution, to Mr. M'Cul-
loch's excellent *Dictionary of Commerce and Commercial Navigation.*

by the miner, and transported by the engineer to the smelting station, are there skilfully blended by the iron-master (manufacturer), who treats them in a furnace appropriately constructed, along with their due proportions of flux and fuel, whereby he reduces them to cast iron of certain quality, which he runs off at the right periods into rough pigs or regular moulds; he then transforms this crude metal, by mechanical and chemical agencies, into bar and plate iron of various sizes and shapes, fit for the general market; he finally converts the best of the bars into steel, by the cementation furnace, the forge, and the tilt-hammer; or the best of the plates into tin-plate. When farther worked by definite and nearly uniform processes into objects of very general demand in all civilized countries, these iron and steel bars still belong to the domain of manufactures; as, for example, when made into anchors, chain-cables, files, nails, needles, wire, &c.; but when the iron is fashioned, into ever varying and capricious forms, they belong either to the general business of the founder and cutler, or to the particular calling of some handicraft, as the locksmith, gratesmith, coachsmith, gunsmith, tinman, &c.

Such are the principles which have served to guide me in selecting articles for the present volume. By them, as a clew, I have endeavored to hold a steady course through the vast and otherwise perplexing labyrinth of arts, manufactures, and mines; avoiding alike engineering and mechanical arts, which cause no change in the texture or constitution of matter,— and handicraft operations, which are multiform, capricious, and hardly susceptible of scientific investigation. In fact, had such topics been introduced into the volume, it would have presented a miscellaneous farrago of incongruous articles, too numerous to allow of their being expounded in a manner either interesting or instructive to the manufacturer and the metallurgist. I readily acknowledge, however, that I have not been able to adhere always so rigorously as I could have wished to the above rule of selection; having been constrained by intelligent and influential friends to introduce a few articles which I would gladly have left to the mechanical engineer. Of these *Printing* is one, which, having had no provision made for it in my original plan, was too hastily compiled to admit of my describing, with suitable figures, the flat-printing automatic machine of Mr. Spottiswoode, wherewith the pages of this volume were worked off; a mechanism which I regard as the most elegant, precise, and productive, hitherto employed to execute the best style of letter press.

I have imbodied in this work the results of my long experience as a Professor of Practical Science. Since the year 1805, when I entered at an early age upon the arduous task of conducting the schools of chemistry and manufactures in the Andersonian Institution, up to the present day, I have been assiduously engaged in the study and improvement of most of the chemical and many of the mechanical arts. Consulted professionally by proprietors of factories, workshops, and mines of various descriptions, both in this country and abroad, concerning derangements in their operations, or defects in their products, I have enjoyed peculiar opportunities of becoming familiar with their minutest details; and have frequently had the good fortune to rectify what was amiss, or to supply what was wanting. Of the stores of information thus acquired, I have availed myself on the present occasion; careful, meanwhile, to neglect no means of knowledge which my extensive intercourse with foreign nations affords.

I therefore humbly hope that this work will prove a valuable contribution to the literature of science, serving —

In the first place, to instruct the Manufacturer, Metallurgist, and Tradesman, in the principles of their respective processes, so as to render them in

reality the masters of their business, and to emancipate them from a state of bondage to such as are two commonly the slaves of blind prejudice and vicious routine.

Secondly, to afford to Merchants, Brokers, Drysalters, Druggists, and Officers of the Revenue, characteristic descriptions of the commodities which pass through their hands.

Thirdly, by exhibiting some of the finest developments of chemistry and physics, to lay open an excellent practical school to students of these kindred sciences.

Fourthly, to teach Capitalists, who may be desirous of placing their funds in some productive bank of industry, to select judiciously among plausible claimants.

Fifthly, to enable Gentlemen of the Law to become well acquainted with the nature of those patent schemes which are so apt to give rise to litigation.

Sixthly, to present to our Legislators such a clear exposition of our staple manufactures, as may dissuade them from enacting laws which obstruct industry, or cherish one branch of it to the injury of many others: and,

Lastly, to give the General Reader, intent chiefly on *intellectual cultivation*, a view of many of the noblest achievements of science, in effecting those grand transformations of matter to which Great Britain owes her paramount wealth, rank, and power among the kingdoms.

The latest statistics of every important object of manufacture is given from the best, and, usually, from official authority, at the end of each article.*

The following summary of our manufactures is extracted from Mr. Macqueen's *General Statistics of the British Empire*, published in 1836. It shows the amount of capital embarked in the various departments of manufacturing industry, and of the returns of that capital :—

	Capital.	Produce.
	£	£
Cotton manufactures - - - - -	40,973,872	52,513,586
Woollen ditto - - - - -	36,000,000	44,250,000
Silk ditto - - - - -	8,000,000	10,000,000
Linen ditto - - - - -	12,000,000	15,421,186
Leather ditto - - - - -	13,000,000	16,000,000
Iron ditto, to making pig iron - - -	10,000,000	7,098,000
Iron, hardware, cutlery, &c. - - - -	25,000,000	31,072,600
Copper and brass ditto - - - - -	3,600,000	4,673,186
China, glass, &c. - - - - -	8,000,000	10,892,794
Paper, furniture, books, &c. - - - -	10,000,000	14,000,000
Spirits (British), ales, soap, &c. - - -	37,600,000	47,163,847
Sundries additional - - - - - -	- -	9,000,000
Totals - - - - - -	201,773,872	262,085,199

In consequence of an arrangement with Mr. William Newton, patent agent, and proprietor of the *London Journal of Arts, Sciences, and Manufactures*, I have been permitted to enrich this Dictionary with many interesting descriptions and illustrative figures of modern patent inventions and improvements, which I could not otherwise have presented to my readers. Mr. Newton has lately enhanced the value of his Journal by annexing to it a *catalogue raisonnée*, entitled " An Analytical Index to the Subjects contained in the 23 Volumes," which constitute the first and second series. The

* The statistics of agriculture, trade, and manufactures is ably and fully discussed in Mr. M'Culloch's *Dictionary* already referred to.

subsequent 22 volumes, of his Conjoined Series, are of still superior interest; and the whole form a vast storehouse of Mechanical and Chemical Invention.

Although I am conscious of having used much diligence for many years in collecting information for this work, from every quarter within my reach, the utmost pains in preparing it for publication, and incessant vigilance during its passage through the press, yet I am fully aware that it must contain several errors and defects. These I have studied to rectify, in the text of this edition, and more completely in a compendious Supplement.

Since this book is not a Methodical Treatise, but a Dictionary, one extensive subject may be necessarily dispersed through many articles. Thus, for example, information upon the manufacture of *Colors* will be found under azure ; black pigment ; bone-black ; bronze ; brown dye ; calico-printing ; carmine ; carthamus ; chromium ; cochineal ; crayons ; dyeing ; enamels ; gold ; gilding ; gamboge ; gray dye ; green dye ; green paints ; indigo ; kermes ; lac dye ; lakes ; madder ; massicot ; mercury ; periodide of ; Naples yellow ; orange dye ; orpiment ; paints ; grinding of ; ochres ; paper-hangings ; pastes ; pearl white ; Persian berries ; pottery pigments ; Prussian blue ; purple of Cassius ; red lead ; rouge ; Scheele's green ; Schweinfurth green ; stained glass ; terra di Sienna ; ultramarine ; umber ; verditer ; vermilion ; vitrifiable colors, weld, white lead ; woad ; yellow, king's.

A casual consulter of the Dictionary, who did not advert to this distribution, might surmise it to be most deficient, where it is in reality most copious

The elaborate and costly Encyclopedias, and Dictionaries of Arts, which have appeared from time to time in this country, and abroad, have, for the most part, treated of the mechanical manufactures more fully and correctly than of the chemical. The operations of the former are, in fact, tolerably obvious and accessible to the inspection of the curious ; nor are they difficult to transfer into a book, with the aid of a draughtsman, even by a person but moderately versed in their principles. But those of the latter are not unfrequently involved in complicated manipulations, and depend, for their success, upon a delicate play of affinities, not to be understood without an operative familiarity with the processes themselves. Having enjoyed the best opportunities of studying the chemical arts upon the greatest scale in this kingdom and on the Continent, I may venture, without the imputation of arrogance, to claim for my work, in this respect, more precision and copiousness than its predecessors possess. I have gone as far in describing several curious processes, hitherto veiled in mystery, as I felt warranted, without breach of confidence, to go ; regarding it as a sacred duty never to publish any secret whatever, without the consent of its proprietor. During my numerous tours through the factory districts of Great Britain, France, &c., many suggestions, however, have been presented to my mind, which I am quite at liberty to communicate in private, or carry into execution, in other districts too remote to excite injurious competition against the original inventors. I am also possessed of many plans of constructing manufactories, of which the limits of this volume did not permit me to avail myself, but which I am ready to furnish, upon moderate terms, to proper applicants. I conclude by pointing attention to the very insecure tenure by which patents for chemical or chemico-mechanical inventions are held ; of which there is hardly one on record which may not be readily evaded by a person skilled in the resources of practical chemistry, or which could stand the ordeal of a court of law, directed by an experienced chemist. The specifications of such patents stand in need of a thorough reform ; being for the most part not only discreditable and delusive to the patentees, but calculated to involve them in one of the greatest of evils—a chancery suit.

A

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ABB-WOOL. Among clothiers, this term signifies the *woof* or *weft*.

ACETATE. (*Acétate*, Fr.; *Essigsaure*, Germ.) Any saline compound of which the acetic is the acid constituent; as acetate of soda, of iron, of copper, &c.

ACETATE OF ALUMINA, see RED LIQUOR and MORDANT; of COPPER, see COPPER; of IRON, see IRON; of LEAD, see LEAD; of LIME, see PYROLIGNEOUS ACID.

ACETIC ACID (*Acide Acétique*, Fr.; *Essigsaure*, Germ.) is the name of the sour principle which exists in vinegar. It occurs, ready formed, in several products of the vegetable kingdom, and is generated during the spontaneous fermentation of many vegetable and animal juices. The *sambucus nigra*, or black elder, the *phœnix dactilifera*, and the *rhus typhinus* are plants which afford a notable quantity of vinegar. It is found, likewise, in the sweat, urine, milk, and stomach of animals. All infusions of animal or vegetable matters in water, when exposed for some time to the air, at a moderate temperature, ferment into vinegar; and most vegetables, when subjected to decomposition by fire, give off condensable vapors of acetic acid. All liquids containing alcohol are susceptible of passing into the state of vinegar; but the pre-existence of alcohol is not necessary to this change, as we learn from the acetification of vegetable soups, infusion of cabbage, starch — paste, &c.

Vinegar may be distinguished into four varieties, according to the mode of its production, though all of them are capable of being converted, by chemical means, into one identical acetic acid. 1. Wine vinegar. 2. Malt vinegar. 3 Sugar vinegar. 4. Wood vinegar, or pyroligneous acid. Fermentation is the source of the acid in the first three varieties. Here alcohol is first generated, and is next converted into vinegar by the influence of the air at a genial temperature; a change which will be investigated under FERMENTATION. But the conversion of spirit of wine into acetic acid may be demonstrated by direct experiment. When the vapor of alcohol is brought into contact in the atmosphere with the black powder obtained by mixing muriate of platina, potash, and alcohol, vinegar is rapidly formed at the expense of the alcohol. In Germany, where crude alcohol bears a low price, the manufacture of vinegar has been arranged upon that principle, which, as throwing some light on the process of acetification, I shall briefly describe. See PLATINUM *for the mode of preparing the above powder.*

Under a large case, which for experimental purposes may be made of glass, several saucer-shaped dishes of pottery or wood are to be placed in rows, upon shelves over each other, a few inches apart. A portion of the black platina powder moistened being suspended over each dish, let as much vinous spirits be put into them as the oxygen of the included air shall be adequate to acidify. This quantity may be inferred from the fact, that 1000 cubic inches of air can oxygenate 110 grains of absolute alcohol, converting them into 122 grains of absolute acetic acid, and 64½ grains of water.

The above simple apparatus is to be set in a light place (in sunshine, if convenient), at a temperature of from 68° to 86° Fahr., and the evaporation of the alcohol is to be promoted by hanging several leaves of porous paper in the case, with their bottom edges dipped in the spirit. In the course of a few minutes, a most interesting phenomenon will be perceived. The mutual action of the platina and the alcohol will be displayed by an increase of temperature, and a generation of acid vapors, which, condensing on the sides of the glass-case, trickle in streams to the bottom. This striking transformation continues till all the oxygen of the air be consumed. If we wish, then, to renew the process, we must open the case for a little, and replenish it with air. With a box of 12 cubic feet in capacity, and with a provision of 7 or 8 ounces of the platina powder,

we can, in the course of a day, convert one pound of alcohol into pure acetic acid, fit for every purpose, culinary or chemical. With from 20 to 30 pounds of the platina powder (which does not waste), we may transform, daily, nearly 300 pounds of bad spirits into the finest vinegar. Though our revenue laws preclude the adoption of this elegant process upon the manufacturing scale in this country, it may be regarded as one of the greatest triumphs of chemistry, where art has rivalled nature in one of her most mysterious operations.

To readers acquainted with chemical symbols, the following numerical representation of the conversion of alcohol into acetic acid may be acceptable :—

$$
\begin{array}{llll}
580{\cdot}64 \text{ parts by weight of alcohol} & = & H^{12} \ C^4 \ O^2 \text{ consist of} \\
74{\cdot}88 & \text{of hydrogen} & = & H^{12} \\
305{\cdot}76 & \text{of carbon} & = & C^4 \\
200{\cdot}00 & \text{of oxygen} & = & O^2
\end{array}
$$

If we combine with this mixture, 400 parts of oxygen $= O^4$, we have,—

$$
\begin{array}{llll}
\text{of water} & = & 337{\cdot}44 & = & H^6 \ O^3 \\
\text{acetic acid} & = & 643{\cdot}20 & = & H^6 \ C^4 \ O^3
\end{array}
$$

Hence, in this formation of vinegar, 100 parts by weight of alcohol take 68·89 parts of oxygen; and there are produced 58·11 parts of water, and 110·78 of acetic acid.

These beautiful experiments prove, that when in a mere mixture of alcohol and water, under the influence of the atmospheric air and heat, some vinegar comes to be formed after a considerable time, the same formation of vinegar takes place in a similar, but more effective, manner, when a ferment is present, which acts here in a somewhat analogous way to the platina powder in the preceding case. Several azotized substances serve as re-agents towards the acetous fermentation,—such as vinegar ready-made, vinegar-yeast, or lees, barley bread, leaven, beer barm, and similar vegetable matters, which contain gluten. The best and purest ferment is, however, vinegar itself With this ferment we must conjoin, as an essential condition of acetification, the free access of atmospheric air.

It is a well-known fact, that spirituous liquors, as weak brandy, wine, and beer, &c., may be preserved for years in close vessels, without undergoing the acetous fermentation, even when they repose upon a layer of lees. It is equally well known, that these very liquors, if they stand for some time in open vessels, become readily sour, especially if exposed, also, to a somewhat high temperature. If we fill a flask with common brandy, and subject it, without a stopper, to the influence of air and warmth, the contained liquor may, at· the end of many weeks, discover no sensible acidity; if we add to the same brandy a ferment, and stop the flask air-tight, everything will still remain unchanged; but if we leave a portion of air in the flask, or leave it uncorked, vinegar will soon make its appearance in the brandy.

If we investigate the nature of the air which remains over brandy in the act of acetification, we shall find that it consists entirely of carbonic acid and azote, the oxygen being absorbed and combined in the acetic acid and water formed.

Since this absorption of oxygen from the air can take place only at the surface of the fermenting liquors, we thus see the necessity and the practical importance of amplifying that surface, in order to accelerate and complete the acetification by multiplying the points of contact between the alcohol and the oxygen. The essence of the new German method of rapid acetification depends upon this principle.

Temperature has also a remarkable influence on the formation of vinegar. The acid fermentation proceeds very feebly in the cold, but takes an accelerated pace as the heat is raised. It would even appear that spirituous vapors brought by themselves in contact with atmospheric air, without the aid of any ferment, are capable of being converted into acetic acid, since it has happened in the rectification of brandy, in a still furnished with a large capital and adopter pipe into which air was allowed to enter, that vinegar made its appearance. Hence, warmth does not seem to act as a promoter of the combination of alcohol with oxygen in a merely chemical point of view, but it acts, so to speak, physically. Over the warm liquor a stratum of spirit vapor appears to float, which, coming there into conflict with the atmospherical oxygen, probably causes the generation of some acetic acid, and thus accelerates the operation, much more than by the mere contact of the oxygen with the liquid surface.

When we expose any spirituous liquors, as wine, beer, &c., with the requisite ferment, to the external air, at a temperature of from 64° to 68° Fahr., the fluid, however clear before, becomes soon turbid; filamentous slimy particles begin to appear moving in the middle and on the sides of the vessel, and then form a scum on the top of the liquor. When this scum has acquired a certain thickness and consistence, it falls in a sediment to the bottom. The Germans call it the vinegar *mother*, as it serves to excite acetification in fresh liquors. Meanwhile, the liquor has become warmer than the sur-

>unding air, and the vinegar process betrays itself by diffusing a peculiar aroma in the partment. Whenever all the alcohol present has been converted into acetic acid, the quor comes into a state of repose; its temperature sinks to the pitch of the atmosphere; becomes bright, and is the article well known by its taste and smell under the name f vinegar.

Genuine wine or raisin vinegar differs from that formed either from apples, or sugar, :er, &c., in containing wine-stone or tartar; by which peculiarity it may be distinguish-l, except in those cases where crude tartar has been artificially added to the other negars, as a disguise. Barley-malt vinegar contains some phosphoric acid, in the state ˙ phosphate of lime or magnesia, derived from the grain.

After these general observations upon acetification, we shall now proceed to describe e process for manufacturing vinegar on the commercial scale.

1. *Wine vinegar.*—The first consideration with a vinegar-maker is a good fermenting om, in which the wines may be exposed to a steady temperature, with an adequate pply of atmospherical air. As this air is soon deprived of its oxygenous constituent, cilities ought to be provided for a renewal of it by moderate ventilation. The air-les for this purpose ought to be so contrived that they may be shut up when the mperature begins to fall too low, or in windy weather. The best mode of com-unicating the proper warmth to a chamber of this kind is by means of fire-flues or hot ater pipes, running along its floor at the sides and ends, as in a hot-house; the fireplace ːing on the outside, so that no dust may be created by it within. The flue is best made ˙ bricks, and may have a cross section of 10 or 12 inches by 15 deep. The soot deposited, ɾen when coals are burned, will find ample space in the bottom of the flue, without terfering essentially with the draught, for a very long period, if it be made of the >ove dimensions. Low-roofed apartments are preferable to high ones; and those built ith thick walls, of imperfectly conducting materials, such as bricks, lined with lath ad plaster work. Should the chamber, however, have a high ceiling, the fermenting ins must be raised to a suitable height on scaffolding, so as to benefit by the warmest ːr. Sometimes the vinegar vessels are placed at different levels; in which case the up-ɛr ones acetify their contents much sooner than the under, unless they are emptied and lled alternately, which is a good plan.

Orleans is the place most famous for vinegars. The building there destined to their ɪanufacture is called a *vinaigrerie*, and is placed, indifferently, either on the ground floor ɾ the floor above it; but it has always a southern exposure, to receive the influence f the sunbeams. The vessels employed for carrying on the fermentation are casks, ɑlled *mothers*. Formerly they were of a large capacity, containing about 460 litres ɪ50 gallons, Eng.); but at the present day they are barrels of half that capacity, or ɒmewhat less than an old English hogshead. It is now known that the wine passes ɒoner into vinegar the smaller the mass operated upon, the more extensive its contact rith the air, and the more genial its warmth. These casks were formerly arranged in hree ranks by means of massive scaffolding; they are now set in four ranks, but they ɛst on much smaller rafters, sustained by uprights, and can be packed closer together. ɾhe casks, which are laid horizontally, are pierced at the upper surface of their front end with two holes: one, to which the name of *eye* is given, is two inches in diameter; it serves for putting in the charge, and drawing off the vinegar when it is made; the other hole is much smaller, and is placed immediately alongside; it is merely an air-hole, and is necessary to allow the air to escape, because the funnel completely fills the other hole in the act of filling the cask.

When new vessels are mounted in a vinegar work, they must be one third filled with the best vinegar that can be procured, which becomes the true *mother* of the vinegar to be made; because it is upon this portion that the wine to be acidified is successively added. At the ordinary rate of work, they put at first upon the *mother*, which occupies one third of the vessel, a *broc* of ten litres of red or white wine; eight days afterwards they add a second *broc*; then a third, and a fourth, always observing the same interval of ˌtime, 8 days. After this last charge, they draw off about forty litres of vinegar, and then recommence the successive additions.

It is necessary that the vessel be always one third empty if we wish the acetification to go on steadily; but as a portion of the tartar and the lees forms and accumulates in the lower part of the cask, so as eventually to counteract the fermentation, the time ar-rives when it is requisite to interrupt it, in order to remove this residuum, by clearing out all the contents. The whole materials must be renovated every 10 years; but the casks, if well made and repaired, will serve for 25 years.

We have mentioned a definite period at which the vinegar may be drawn off; but that wɑs on the supposition that the process had all the success we could wish; there are circumstances, difficult to appreciate, which modify its progress, as we shall presently ʃow. We ought, therefore, before discharging the vinegar, to test and see if the fer-

mentation has been complete. We proceed as follows: we plunge into the liquor a white stick or rod, bent at one end, and then draw it out in a horizontal direction: if it be covered with a white thick froth, to which is given the name of *work (travail)*, we judge that the operation is terminated; but if the work, instead of being white and pearly, be red, the manufacturers regard the fermentation to be unfinished, and they endeavor to make it advance, by adding fresh wine, or by increasing the heat of the apartment.

It is not always easy to explain why the fermentation does not go on as rapidly in one case as in another. There are even certain things which seem at present to be entirely inexplicable. It happens sometimes, for example, that although all the vessels have been equally charged, and with the same wine, yet the fermentation does not form in the same manner in the whole; it will move rapidly in some, be languid, or altogether inert, in others. This is a very puzzling anomaly; which has been ascribed to electrical and other obscure causes, because it is not owing to want of heat, the casks in the warmest positions being frequently in fault; nor to the timber of the cask. It, however, para-lyzes the process so completely that the most expert vinegar makers have nothing else for it, when this accident happens, than to empty entirely what they call the lazy cask, and to fill it with their best vinegar. The fermentation now begins, and proceeds as well in it as in the others. See FERMENTATION.

We must here make an important remark, relatively to the temperature which should prevail in the fermentation room. In many chemical works we find it stated, that the heat should not exceed 18° R., or 65° Fahr., for fear of obtaining bad products. But the vinegar makers constantly keep up the heat at from 24° to 25° R., 75° to 77° F.; when the acetification advances much more rapidly, and the vinegar is equally strong. The best proof of this heat not being too high is, that under it, the vessels in the upper part of the room, work best and quickest. In Orleans, cast-iron stoves and wood fuel are used for communicating the requisite warmth.

Before pouring the wine into the *mothers*, it is clarified in the following manner. There are tuns which can contain from 12 to 15 pieces of wine. Their upper end has at its centre an opening of four or five inches diameter, which may be closed after-wards with a wooden cover; this opening is for the purpose of receiving a large funnel. The inside of the tun is filled with chips of beechwood, well pressed down. The wine is poured upon these chips, allowed to remain for some time, and then gently drawn off by a pipe in the lower part of the vessel. The lees are deposited upon the chips, and the wine runs off quite clear. However, it happens sometimes, notwithstanding this precaution, that the vinegar, after it is made, requires to be clarified, more particularly if the wine employed had been weak. The vinegar must be filtered in the same way; and it derives an advantage from it, as the products of different casks get thereby mixed and made uniform.

By this Orleans method several weeks elapse before the acetification is finished; but a plan has been lately devised in Germany to quicken greatly the acid fermentation by pe-culiar constructions. This system is called, the *quick* vinegar work, because it will com plete the process in the course of 2 or 3 days, or even in a shorter time. It depends, chiefly, upon the peculiar construction of the fermenting vessels, whereby the vinous liquor is exposed on a vastly expanded surface to the action of the atmospheric air.

An oaken tub, somewhat narrower at the bottom than the top, from 6 to 7 feet high and 3 feet in diameter, is furnished with a well-fitted grooved, but loose, cover. About half a foot from its mouth, the tub has a strong oak or beech hoop fitted to its inside surface, sufficiently firm to support a second cover, also well fitted, but moveable. The space under this second cover is destined to contain the vinous liquor, and in order to bring it very amply into contact with the atmosphere, the following contrivances have been resorted to: This cover is perforated, like a sieve, with small holes of from 1 to 2 lines in diameter, and about 1½ inch apart. Through each of these holes a wick of pack-thread or cotton is drawn, about 6 inches long, which is prevented from falling through by a knot on its upper end, while its under part hangs free in the lower space. The wicks must be just so thick as to allow of the liquor poured above the cover passing through the holes in drops. The edges of the lid must be packed with tow or hemp to prevent the liquor running down through the interval.

The whole lower compartment is now to be filled with chips of beechwood up to nearly the perforated cover. The liquor, as it trickles through the holes, diffuses itself over the chips, and, sinking slowly, collects at the bottom of the tub. The chips should be prepared for this purpose by being repeatedly scalded in boiling water, then dried, and imbued with hot vinegar. The same measures may also be adopted for the tub. To provide for the renewal of the air, the tub is perforated at about a foot from its bottom with eight holes, set equally apart round the circumference, two thirds of an inch wide, and sloping down, through which the air may enter into this lower compartment, without the trickling liquor being allowed to flow out. In order that the foul air which has

become useless may escape, four large holes are pierced in the sieve cover, at equal distances asunder and from the centre, whose united areas are rather smaller than the total areas of the holes in the side of the tub. Into these four holes open glass tubes must be inserted, so as to stand some inches above the cover, and to prevent any of the liquor from running through them. The proper circulation of the air takes place through these draught holes. This air may afterwards pass off through a hole of 2½ inches diameter in the uppermost cover, in which a funnel is placed for the supply of liquor as it is wanted to keep up the percolation.

The temperature of the fermenting compartment is ascertained by means of a thermometer, whose bulb is inserted in a hole through its side, and fastened by a perforated cork. The liquor collected in the under vessel runs off by a syphon inserted near its bottom, the leg of which turns up to nearly the level of the ventilating air pipes before it is bent outwards and downwards. Thus the liquor will begin to flow out of the under compartment only when it stands in it a little below the sieve cover, and then it will run slowly off at the inclined mouth of the syphon, at a level of about 3 inches below the lower end of the glass tubes. There is a vessel placed below, upon the ground, to receive it. The tub itself is supported upon a wooden frame, or a pier of brickwork, a foot or 18 inches high.

A tub constructed like the above is called a GRADUATION VESSEL, which see. It is worked in the following way :—The vinegar room must be, in the first place, heated to from 100° to 110° F., or till the thermometer in the graduation vessel indicates at least 77°. The heat may then be modified. We now pour through the uppermost cover of the tub a mixture, warmed to 144° F., of 8 parts proof spirits, 25 parts soft water, 15 parts of good vinegar, and as much clear wine or beer. The water should be first heated, and then the vinegar, spirits, and wine may be added to it. Of this mixture, so much should be poured in as is necessary to cover over the second lid, 2 or 3 inches deep, with the liquor; after which, the rest may be poured slowly in, as it is wanted.

When the liquor has run for the first time through the graduation vessel, it is not yet sufficiently acidified; but the weak vinegar collected in the exterior receiving cistern must be a second time, and, if need be, a third time, passed through the graduation tub, in order to convert all the alcohol into acetic acid. In general, we may remark, that the stronger the vinous liquor the more difficult and tedious is its conversion into vinegar, but it is so much the stronger. To lessen this difficulty somewhat, it would be well not to put all the spirits at first into the wash, or mixed liquors, but to add a little more of it at the second and the third running, especially when we desire to have very strong vinegar.

After the graduation vessel has been some days at work, it is no longer necessary to add vinegar to the mixture of spirits and water, since the sides of the graduation tub, the beech chips, and the packthreads, are all impregnated with the ferment, and supply its place. The mixture must, however, be always maintained at the temperature of 100°.

Instead of the above mixture of brandy, water, and wine, we may employ, according to Dingler, a clear fermented wort of malt, mixed with a little spirits. The perfect vinegar, which collects in the receiving cistern, may be immediately racked off into the store casks for sale.

It has been objected to this process, that, in consequence of the mixture of saccharine and glutinous materials, which are contained in beer or worts, along with the acetous fermentation, there is also, partially, a vinous fermentation, and much carbonic acid, thereby disengaged, so as to obstruct the acetification. This obstruction may be remedied by a freer circulation of air, or by the exposure of quicklime in the chamber. It is a more substantial objection, that, from the addition of beer, &c., more lees, or dregs, are deposited in the graduation tub, whereby a more frequent cleansing of it, and of the beech chips, with a loss of time and vinegar, becomes necessary. The only mode of obviating this difficulty is, to take well-clarified fermented wash.

Another evil attendant on the quick process is, the evaporation of the spirituous liquors. Since, in the graduation tub, there is a temperature of 110°, it is impossible to avoid a loss of spirit from the circulation and efflux of the air. The air, indeed, that issues from the top hole in the uppermost cover, might be conducted over an extensive surface of fresh water, where its spirit would be condensed in a great measure. But, after all, this fear of great loss is, I believe, groundless; because the spirit is rapidly acidified by the oxygen of the air, and thereby rapidly loses its volatility.

The supply of the warm wash should be drawn from a cistern placed near the ceiling, where the temperature of the apartment is hottest; and it may be replenished from the partly acidified liquor in the cistern on the floor. With this view, two cisterns should be placed above, so that one of them may always contain liquor sufficiently hot, and thus the process will suffer no interruption.

When malt wash is used for this quick process, the resulting vinegar must be clarified

in a tun with beech chips, as above described. In two or three days the impurities will be deposited, and the fine vinegar may be racked off.

The following prescription, for preparing what he calls malt wine, is given by Dr. Kastner. Eighty pounds of pale barley malt, and 40 pounds of pale wheat malt, are to be crushed together. These 120 pounds are to be infused with 150 quarts of water, at the temperature of 122° Fahr., afterwards with 300 quarts of boiling water, and the whole body is to be mashed thoroughly, till all the lumps disappear. It is then to be left at rest in a large covered tub, for two or three hours, to allow the grains to settle down, from which the wort is to be drawn off. When it has fallen to the temperature of 64° Fahr., 15 pounds of good yeast are to be stirred in, and it must now be left for two or three days to ferment, in a loosely covered tun. When the vinous fermentation has taken place, the clear liquor must be drawn off by a tap hole, a little above the bottom, so as to leave the lees and scum in the tun. This malt wine, he adds, may be kept for a long time in close vessels, and is always ready for making quick vinegar.

2. *Malt Vinegar.*—The greater part of British vinegar is made from malt, by the following process:—1 boll of good barley malt, properly crushed, is to be mashed with water at 160° Fahr. The first water should have that temperature; the second must be hotter than 160°, and the third water, for the extraction of all the soluble matter, may be boiling hot. Upon the whole, not more than 100 gallons of wort should be extracted. After the liquor has cooled to 75° Fahr., 3 or 4 gallons of beer yeast are poured in, and well mixed with a proper stirrer. In 36 or 40 hours, according to the temperature of the air, and the fermenting quality of the wash, it is racked off into casks, which are laid upon their sides in the fermenting apartment of the vinegar work, which should be kept at a temperature of 70° at least; in summer partly by the heat of the sun, but in general by the agency of proper stoves, as above described. The bung-holes should be left open, and the casks should not be full, in order that the air may act over an extensive surface of the liquor. It would be proper to secure a freer circulation to the air, by boring a hole in each end of the cask, near its upper edge. As the liquor, by evaporation, would be generally a few degrees colder than the air of the apartment, a circulation of air would be established in at the bung-hole, and out by the end holes. By the ordinary methods, three months are required to make this vinegar marketable, or fit for the manufacture of sugar of lead.

In making vinegar for domestic purposes, the casks are usually set on their ends; and they have, sometimes, a false bottom, pierced with holes, placed about a foot above the true one. On this bottom, a quantity of *rape*, or the refuse raisins, &c. from the making of British wines, is laid. The malt liquor has a proper quantity of yeast added to it. In about 24 hours it becomes warm, and is then racked off into another similar cask. After some time, this racking process is discontinued, and the vinegar is allowed to complete its fermentation quietly. The proper temperature must always be kept up, by placing the cask in a warm situation. A little wine-stone (*argal*) added to the malt wash, would make the vinegar liker that made from wine. Sometimes a little isinglass is employed to clarify vinegar. A portion of sulphuric acid is often added to it.

3. *Sugar Vinegar.*—By pursuing the following plan, an excellent sugar vinegar may be made. In 158 quarts of boiling water dissolve 10 pounds of sugar, and 6 pounds of wine-stone; put the solution into a fermenting cask, and when it is cooled to the temperature of from 75° to 80°, add 4 quarts of beer yeast to it. Stir the mixture well, then cover the vessel loosely, and expose it for 6 or 8 days to the vinous fermentation, at a temperature of from 70° to 75° Fahr. When it has become clear, draw off the vinous liquor, and either acetify it in the graduation tub above described, or by the common vinegar process. Before it is finished, we should add to it 12 quarts of strong spirits (brandy), and 15 quarts of good vinegar, to complete the acetous fermentation. With a graduation tub which has been used, this addition of vinegar is unnecessary.

The following simpler prescription for making sugar vinegar deserves attention. For every gallon of hot water take 18 ounces of sugar; and when the sirup has cooled to 75°, add 4 per cent., by measure, of yeast. When the vinous fermentation is pretty well advanced, in the course of 2 or 3 days, rack off the clear wash from the lees into a proper cask, and add 1 ounce of wine-stone, and 1 of crushed raisins, for every gallon of water. Expose it in a proper manner, and for a proper time, to the acetifying process; and then rack off the vinegar, and fine it upon beech chips. It should be afterwards put into bottles, which are to be well corked.

Vinegar obtained by the preceding methods has always a yellowish or brownish color. It may be rendered colorless by distillation. For nicer chemical purposes, this is done in a glass retort; but on a large scale, it is usually performed in a clean copper still, furnished with a capital and worm-refrigeratory, either of silver or block tin. It is volatile at the boiling temperature of water; and if the process be carried on briskly, it will not sensibly corrode the copper. But we can never obtain, in this way, a strong article; for, as soon as the vinegar gets concentrated to a certain degree, we

cannot force off the remainder by heat, for fear of giving it an empyreumatic odor; because the gluten, coloring matter, &c. begin to adhere to the bottom of the still. We are, therefore, obliged to suspend the operation at the very time when the acid is acquiring strength. It has been also proposed to concentrate vinegar by the process of congelation; but much of it remains entangled among the frozen water; and common distilled vinegar is so weak, that it congeals in one mass.

Before the process for pyroligneous acid, or wood vinegar, was known, there was only one method of obtaining strong vinegar practised by chemists; and it is still followed by some operators, to prepare what is called radical or aromatic vinegar. This consists in decomposing, by heat alone, the crystallized binacetate of copper, commonly, but improperly, called distilled verdigris. With this view, we take a stoneware retort (*fig.* 1),
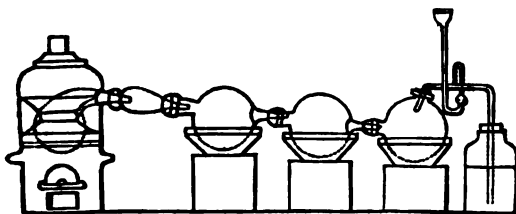

Fig. 1.

of a size suited to the quantity we wish to operate upon; and coat it with a mixture of fire clay and horsedung, to make it stand the heat better. When this coating is dry, we introduce into the retort the crystallized acetate slightly bruised, but very dry; we fill it as far as it will hold without spilling when the beak is considerably inclined. We then set it in a proper furnace. We attach to its neck an adopter pipe, and two or three globes with opposite tubulures, and a last globe with a vertical tubulure. The apparatus is terminated by a Welter's tube, with a double branch; the shorter issues from the last globe, and the other dips into a flask filled with distilled vinegar. Everything being thus arranged, we lute the joinings with a putty made of pipeclay and linseed oil, and cover them with glue paper. Each globe is placed in a separate basin of cold water, or the whole may be put into an oblong trough, through which a constant stream of cold water is made to flow. The tubes must be allowed a day to dry. Next day we proceed to the distillation, tempering the heat very nicely at the beginning, and increasing it by very slow degrees till we see the drops follow each other pretty rapidly from the neck of the retort, or the end of the adopter tube. The vapors which pass over are very hot, whence a series of globes are necessary to condense them. We should renew, from time to time, the water of the basins, and keep moist pieces of cloth upon the globes; but this demands great care, especially if the fire be a little too brisk, for the vessels become, in that case, so hot, that they would infallibly be broken, if touched suddenly with cold water. It is always easy for us to regulate this operation, according to the emission of gas from the extremity of the apparatus. When the air bubbles succeed each other with great rapidity, we must damp the fire.

The liquor which passes in the first half hour is weakest; it proceeds, in some measure, from a little water sometimes left in the crystals, which when well made, however, ought to be anhydrous. A period arrives towards the middle of the process when we see the extremity of the beak of the retort, and of the adopter, covered with crystals of a lamellar or needle shape, and of a pale green tint. By degrees these crystals are carried into the condensed liquid by the acid vapors, and give a color to the product. These crystals are merely some of the cupreous salt forced over by the heat. As the process approaches its conclusion, we find more difficulty in raising the vapors; and we must then augment the intensity of the heat, in order to continue their disengagement. Finally, we judge that the process is altogether finished, when the globes become cold, notwithstanding the furnace is at the hottest, and when no more vapors are evolved. The fire may then be allowed to go out, and the retort to cool.

As the acid thus obtained is slightly tinged with copper, it must be rectified before bringing it into the market. For this purpose we may make use of the same apparatus, only substituting for the stoneware retort a glass one, placed in a sand bath. All the globes ought to be perfectly clean and dry. The distillation is to be conducted in the usual way. If we divide the product into thirds, the first yields the feeblest acid, and the third the strongest. We should not push the process quite to dryness, because there remain in the last portions certain impurities, which would injure the flavor of the acid.

The total acid thus obtained forms nearly one half of the weight of the acetate employed, and the residuum forms three tenths; so that about two tenths of the acid have been decomposed by the heat, and are lost. As the oxyde of copper is readily reduced to the metallic state, its oxygen goes to the elements of one part of the acid, and forms water, which mingles with the products of carbonic acid, carbureted hydrogen, and

carbonic oxyde gases which are disengaged : and there remains in the retort some char-
coal mixed with metallic copper. These two combustibles are in such a state of division,
that the residuum is pyrophoric. Hence it often takes fire the moment of its being re-
moved from the cold retort. The very considerable less experienced in this operation
has induced chemists to try different methods to obtain all the acid contained in the ace-
tate. Thus, for example, a certain addition of sulphuric acid has been prescribed ; but,
besides that the radical vinegar obtained in this way always contains sulphurous acid,
from which it is difficult to free it, it is thereby deprived of that spirit called the pyro-
acetic, which tempers the sharpness of its smell, and gives an agreeable aroma. It is to
be presumed, therefore, that the preceding process will continue to be preferred for mak-
ing aromatic vinegar. Its odor is often further modified by essential oils, such as those
of rosemary, lavender, &c.

4. *Pyroligneous Acid, or Wood Vinegar.*—The process for making this acid is founded
upon the general property of heat, to separate the elements of vegetable substances, and
to unite them anew in another order, with the production of compounds which did not
exist in the bodies subjected to its action. The respective proportion of these products
varies, not only in the different substances, but also in the same substance, according as
the degree of heat has been greater or less, or conducted with more or less skill. When
we distil a vegetable body in a close vessel, we obtain at first the included water, or that
of vegetation ; there is next formed another portion of water, at the expense of the oxy-
gen and hydrogen of the body ; a proportional quantity of charcoal is set free, and, with
the successive increase of the heat, a small portion of charcoal combines with the oxygen
and hydrogen to form acetic acid. This was considered, for some time, as a peculiar acid,
and was accordingly called *pyroligneous* acid. As the proportion of carbon becomes
preponderant, it combines with the other principles, and then some empyreumatic oil is
volatilized, of little color, but which becomes thicker, and of a darker tint, always getting
more loaded with carbon.

Several elastic fluids accompany these different products. Carbonic acid comes over,
but in small quantity, much carburreted hydrogen, and, towards the end, a considerable
proportion of carbonic oxyde. The remainder of the charcoal, which could not be carried
off in these several combinations, is found in the retort, and preserves, usually, the form
of the vegetable body which furnished it. Since mankind have begun to reason on the
different operations of the arts, and to raise them to a level with scientific researches,
they have introduced into several branches of manufacture a multitude of improvements,
of which, formerly, they would hardly have deemed them susceptible. Thus, in particu-
lar, the process for carbonizing wood has been singularly meliorated, and in reference to
the preceding observations, advantage has been derived from several products that for-
merly were not even collected.

The apparatus employed for obtaining crude vinegar from wood, by the agency of heat,

Fig. 2.
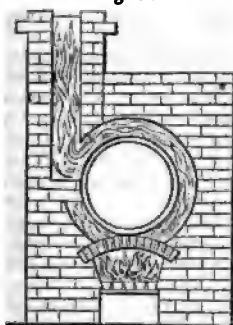
are large iron cylinders. In this country they are made
of cast iron, and are laid horizontally in the furnace; in
France, they are made of sheet iron riveted together, and
they are set upright in the fire. *Fig.* 2 will give an ac-
curate idea of the British plan, which is much the same as
that adopted for decomposing pit coal in gas works, only
that the cylinders for the pyroligneous acid manufacture are
generally larger, being frequently 4 feet in diameter, and
6 or 8 feet long, and built horizontally in brickwork, so
that the flame of one furnace may play around two of
them. It would probably answer better, if their size were
brought nearer the dimensions of the gas-light retorts, and
if the whole system of working them were assimilated to
that of coal gas.

The following arrangement is adopted in an excellent esta-
blishment in Glasgow, where the above large cylinders are
6 feet long, and both ends of them project a very little beyond
the brickwork. One end has a disc or round plate of cast iron, well fitted, and firmly bolted
to it, from the centre of which disc an iron tube, about 6 inches diameter, proceeds and
enters, at a right angle, the main tube of refrigeration. The diameter of this tube may be
from 9 to 14 inches, according to the number of cylinders. The other end of the cylinder
is called the mouth of the retort ; this is closed by a disc of iron, smeared round its edge
by clay lute, and secured in its place by fir wedges. The charge of wood for such a cylin-
der is about 8 cwt. The hard woods—oak, ash, birch, and beech—are alone used ; fir does
not answer. The heat is kept up during the day-time, and the furnace is allowed to cool
during the night. Next morning the door is opened, the charcoal removed, and a new
charge of wood is introduced. The average product of crude vinegar called pyrolig-
neous acid, is 35 gallons. It is much contaminated with tar, is of a deep brown color,

and has a sp. gr. of 1·025. Its total weight is therefore about 300 lbs., but the residuary charcoal is found to weigh no more than one fifth of the wood employed; hence nearly one half of the ponderable matter of the wood is dissipated in incondensable gases. Count Rumford states, that the charcoal is equal in weight to more than four tenths of the wood from which it is made. The count's error seems to have arisen from the slight heat of an oven to which his wood was exposed in a glass cylinder. The result now given, is the experience of an eminent manufacturing chemist.

The crude pyroligneous acid is rectified by a second distillation in a copper still, in the body of which about twenty gallons of viscid tarry matter are left from every 100. It has now become a transparent brown vinegar, having a considerably empyreumatic smell, and a sp. gr. of 1·013. Its acid powers are superior to those of the best household vinegar, in the proportion of three to two. By redistillation, saturation with quick-lime, evaporation of the liquid acetate to dryness, and conversion into acetate of soda by sulphate of soda, the empyreumatic matter is so completely dissipated, that on decomposing the pure acetate of soda by sulphuric acid, a perfectly colorless and grateful vinegar rises in distillation. Its strength will be proportionable to the concentration of the decomposing acid.

The acetic acid of the chemist may be prepared also in the following modes :—1. Two parts of fused acetate of potash, with one of the strongest oil of vitriol, yield, by slow distillation from a glass retort into a refrigerated receiver, concentrated acetic acid. A small portion of sulphurous acid, which contaminates it, may be removed by redistillation from a little acetate of lead. 2. Or four parts of good sugar of lead, with one part of sulphuric acid, treated in the same way, afford a slightly weaker acetic acid. 3. Gently calcined sulphate of iron, or green vitriol, mixed with sugar of lead, in the proportion of 1 of the fo mer to 2½ of the latter, or with acetate of copper, and carefully distilled from a porcelain retort into a cool receiver, may be also considered an economical process. But that with binacetate of copper above described, is preferable to any of these.

Fg. 3.

Fig. 4.
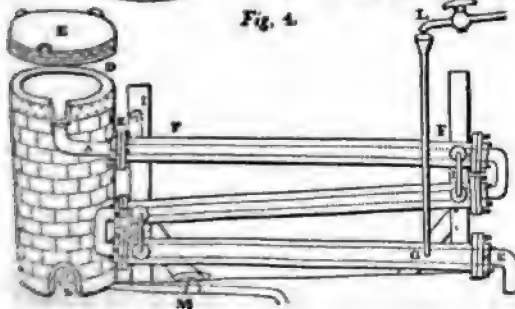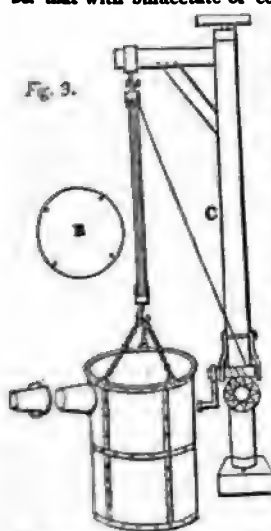
The manufacture of pyroligneous acid is conducted in the following way in France. Into large cylindrical vessels (fig. 3) made of riveted sheet iron, and having at their top and side a small sheet iron cylinder, the wood intended for making charcoal is introduced. To the upper part of this vessel a cover of sheet iron, B, is adapted, which is fixed with bolts. This vessel, thus closed, represents, as we see, a vast retort. When it is prepared, as we have said, it is lifted by means of a swing crane, C, and placed in a furnace, D (fig. 4), of a form relative to that of the vessel, and the opening of the furnace is covered with a dome, E, made of masonry or brickwork. The whole being thus arranged, heat is applied in the furnace at the bottom. The moisture of the wood is first dissipated, but by degrees the liquor ceases to be transparent, and becomes sooty. An adopter tube, A, is then fitted to the lateral cylinder. This adopter enters into another tube at the same degree of inclination which commences the condensing apparatus. The means of condensation vary according to the localities. In certain works they cool by means of air, by making the vapor pass through a long series of cylinders, or sometimes, even, through a series of casks connected together; but most usually water is used for condensing, when it can be easily procured in abundance. The most simple apparatus employed for this purpose consists of two cylinders, F, F (fig. 4), the one within the other, and which leave between them a sufficient space to allow a considerable body of water to circulate along and cool the vapors. This double cylinder is adapted to the distilling vessel, and placed at a certain inclination. To the first double tube, F, F, a second, and

sometimes a third, entirely similar, are connected, which, to save space, return upon themselves in a zigzag fashion. The water is set in circulation by an ingenious means now adopted in many different manufactories. From the lower extremity, G, of the system of condensers, a perpendicular tube rises, whose length should be a little more than the most elevated point of the system. The water, furnished by a reservoir, L, enters by means of the perpendicular tube through the lower part of the system, and fills the whole space between the double cylinders. When the apparatus is in action, the vapors, as they condense, raise the temperature of the water, which, by the column in L G, is pressed to the upper part of the cylinders, and runs over by the spout K. To this point a very short tube is attached, which is bent towards the ground, and serves as an overflow.

The condensing apparatus is terminated by a conduit in bricks covered and sunk in the ground. At the extremity of this species of gutter is a bent tube, E, which discharges the liquid product into the first cistern. When it is full, it empties itself, by means of an overflow pipe, into a great reservoir: the tube which terminates the gutter plunges into the liquid, and thus intercepts communication with the inside of the apparatus. The disengaged gas is brought back by means of pipes M L, from one of the sides of the conduit to the under part of the ash pit of the furnace. These pipes are furnished with stopcocks M, that some distance in front of the furnace, for the purpose of regulating the jet of the gas, and interrupting, at pleasure, communication with the inside of the apparatus. The part of the pipes which terminates in the furnace rises perpendicularly several inches above the ground, and is expanded like the rose of a watering can, N. The gas, by means of this disposition, can distribute itself uniformly under the vessel, without suffering the pipe which conducts it to be obstructed by the fuel or the ashes.

The temperature necessary to effect the carbonization is not considerable: however, at the last it is raised so high as to make the vessels red hot; and the duration of the process is necessarily proportional to the quantity of wood carbonized. For a vessel which shall contain about 5 meters cube (nearly 6 cubic yds.), 8 hours of fire is sufficient. It is known that the carbonization is complete by the color of the flame of the gas: it is first of a yellowish red; it becomes afterwards blue, when more carbonic oxyde than carbonic hydrogen is evolved; and towards the end it becomes entirely white,— a circumstance owing, probably, to the furnace being more heated at this period, and the combustion being more complete. There is still another means of knowing the state of the process, to which recourse is more frequently had; that is the cooling of the first tubes, which are not surrounded with water: a few drops of this fluid are thrown upon their surface, and if they evaporate quietly, it is judged that the calcination is sufficient. The adopter tube is then unluted, and is slid into its junction pipe; the orifices are immediately stopped with plates of iron and plaster loam. The brick cover, E, of the furnace is first removed by means of the swing crane, then the cylinder itself is lifted out and replaced immediately by another one previously charged. When the cylinder which has been taken out of the furnace is entirely cooled, its cover is removed, and the charcoal is emptied. Five cubic meters of wood furnish about 7 chaldrons (voies) and a half of charcoal. (For modifications of the wood-vinegar apparatus, see CHARCOAL and PYROLIGNEOUS ACID.)

The different qualities of wood employed in this operation give nearly similar products in reference to the acid; but this is not the case with the charcoal, for it is better the harder the wood; and it has been remarked that wood long exposed to the air furnishes a charcoal of a worse quality than wood carbonized soon after it is cut.

Having described the kind of apparatus employed to obtain pyroligneous acid, I shall now detail the best mode of purifying it. This acid has a reddish brown color; it holds in solution a portion of empyreumatic oil and of the tar which were formed at the same time, another portion of these products is in the state of a simple mixture: the latter may be separated by repose alone. It is stated above, that the distilling apparatus terminates in a subterranean reservoir, where the products of all the vessels are mixed. A common pump communicates with the reservoir, and sinks to its very bottom, in order that it may draw off only the stratum of tar, which, according to its greater density, occupies the lower part. From time to time the pump is worked to remove the tar as it is deposited. The reservoir has at its top an overflow pipe, which discharges the clearest acid into a cistern, from which it is taken by means of a second pump.

The pyroligneous acid thus separated from the undissolved tar is transferred from this cistern into large sheet iron boilers, where its saturation is effected either by quicklime or by chalk, the latter of which is preferable, as the lime is apt to take some of the tar into combination. The acid parts by saturation with a new portion of the tar, which is removed by skimmers. The neutral solution is then allowed to rest for a sufficient time to let its clear parts be drawn off by decantation.

The acetate of lime thus obtained indicates by the hydrometer, before being mixed with the waters of edulcoration, a degree corresponding to the acidimetric degree of the acid

employed. This solution must be evaporated till it reaches a specific gravity of 1·114 (15° Baumé), after which there is added to it a saturated solution of sulphate of soda. The acids exchange bases; sulphate of lime precipitates, and acetate of soda remains in solution. In some manufactures, instead of pursuing the above plan, the sulphate of soda is dissolved in the hot pyroligneous acid, which is afterwards saturated with chalk or lime. By this means no water need be employed to dissolve the sulphate, and accordingly the liquor is obtained in a concentrated form without evaporation. In both modes the sulphate of lime is allowed to settle, and the solution of acetate of soda is decanted. The residuum is set aside to be edulcorated, and the last waters are employed for washing fresh portions.

The acetate of soda which results from this double decomposition is afterwards evaporated till it attains to the density of 1·225 or 1·23, according to the season. This solution is poured into large crystallizing vessels, from which, at the end of 3 or 4 days, according to their capacity, the mother waters are decanted, and a first crystallization is obtained of rhomboidal prisms, which are highly colored and very bulky. Their facettes are finely polished, and their edges very sharp. The mother waters are submitted to successive evaporations and crystallizations till they refuse to crystallize, and they are then burnt to convert them into carbonate of soda.

To avoid guesswork proportions, which are always injurious, by the loss of time which they occasion, and by the bad results to which they often lead, we should determine experimentally, beforehand, the quantities absolutely necessary for the reciprocal decomposition, especially when we change the acid or the sulphate. But it may be remarked that, notwithstanding all the precautions we can take, there is always a notable quantity of sulphate of soda and acetic acid, which disappear totally in this decomposition. This arises from the circumstance that sulphate of soda and acetate of lime do not completely decompose each other, as I have ascertained by experiments on a very considerable scale; and thus a portion of each of them is always lost with the mother waters. It might be supposed that by calcining the acetate of lime we could completely destroy its empyreumatic oil; but, though I have made many experiments with this view, I never could obtain an acetate capable of affording a tolerable acid. Some manufacturers prefer to make the acetate of soda by direct saturation of the acid with the alkali, and think that the higher price of this substance is compensated by the economy of time and fuel which it produces.

The acetate of soda is easily purified by crystallizations and torrefaction; the latter process, when well conducted, freeing it completely from every particle of tar. This torrefaction, to which the name of fusion may be given, requires great care and dexterity. It is usually done in shallow cast iron boilers of a hemispherical shape. During all the time that the heat of about 500° Fahr. is applied, the fused mass must be diligently worked with rakes; an operation which continues about 24 hours for half a ton of materials. We must carefully avoid raising the temperature so high as to decompose the acetate, and be sure that the heat is equally distributed; for if any point of the mass enters into decomposition, it is propagated with such rapidity, as to be excessively difficult to stop its progress in destroying the whole. The heat should never be so great as to disengage any smoke, even when the whole acetate is liquefied. When there is no more frothing up, and the mass flows like oil, the operation is finished. It is now allowed to cool in a body, or it may be ladled out into moulds, which is preferable.

When the acetate is dissolved in water, the charcoaly matter proceeding from the decomposition of the tar must be separated by filtration, or by boiling up the liquor to the specific gravity 1·114, when the carbonaceous matter falls to the bottom. On evaporating the clear liquor, we obtain an acetate perfectly fine, which yields beautiful crystals on cooling. In this state of purity it is decomposed by sulphuric acid, in order to separate its acetic acid.

This last operation, however simple it appears, requires no little care and skill. The acetate of soda crystallized and ground is put into a copper, and the necessary quantity of sulphuric acid of 1·842 (about 35 per cent. of the salt) to decompose almost, but not all, the acetate, is poured on. The materials are left to act on each other; by degrees the acetic acid quits its combination, and swims upon the surface; the greater part of the resulting sulphate of soda falls in a pulverulent form, or in small granular crystals, to the bottom. Another portion remains dissolved in the liquid, which has a specific gravity of 1·08. By distillation we separate this remainder of the sulphate, and finally obtain acetic acid, having a specific gravity of 1·05, an agreeable taste and smell, though towards the end it becomes a little empyreumatic, and colored; for which reason, the last portions must be kept apart. The acid destined for table use ought to be distilled in an alembic whose capital and condensing worm are of silver; and to make it very fine, it may be afterwards infused over a little washed bone-black. It is usually obtained in a pretty concentrated state; but when we wish to give it the highest degree of concentration, we mix with it a quantity of dry muriate of lime, and distil anew. This acid may

be afterwards exposed to congelation, when the strongest will crystallize. It is decanted, and the crystals are melted by exposing them to a temperature of from 60° to 70° Fahr. this process is repeated till the acid congeals without remainder, at the temperature of 55° Fahr. It has then attained its maximum strength, and has a specific gravity of 1.063.

We shall add an observation on the above mode of decomposing the acetate of soda by sulphuric acid. Many difficulties are experienced in this process, if the sulphuric acid be poured on in small quantities at a time; for then such acrid fumes of acetic acid are disengaged, that the workmen are obliged to retire. This inconvenience may be saved by adding all the sulphuric acid at once; it occupies the lower part of the vessel, and decomposes only the portion of the acetate in contact with it; the heat evolved in consequence of this reaction is diffused through a great mass, and produces no sensible effect. When the sulphuric acid forms an opening, or a species of little crater, the workman, by means of a rake, depresses the acetate into it by degrees, and then the decomposition proceeds as slowly as he desires.

The acetic acid, like the nitric, chloric, and some others, has not hitherto been obtained free from water, and the greatest degree of concentration which we have been able to give it is that in which it contains only the quantity of water equivalent to the atomic weight of another oxydized body; a quantity which amounts to 14·89 per cent. Th processes prescribed for preparing concentrated acetic acid sometimes tend to deprive it of that water without which it could not exist: hence, in all such cases, there is a part of the acid itself decomposed to furnish the water necessary to the constitution of the remainder. The constituent principles of the decomposed portion then form a peculiar, intoxicating, highly inflammatory liquid, called the PYRO-ACETIC SPIRIT.

The most highly concentrated acid of 1·063 becomes denser by the addition of a certain quantity of water up to a certain point. According to Berzelius, the prime equivalent of this acid is 643·189, oxygen being reckoned 100. Now, the above strongest acid consists of one prime of acid, and one of water = 1124·79. When it contains three atoms of water, that is, 337·437 parts to 643·189, or 34·41 to 65·59 in 100, it then has taken its maximum density of 1·075; after which the further addition of water diminishes its specific gravity, as the following table of Mollerat shows. His supposed anhydrous or dry acid contains, at 1·0630, 0·114 parts of water.

Table of Acetic Acid.

Water in 100 parts.	Specific gravity.	Water in 100 parts.	Specific gravity.
0·00	1·0630	33·83	1·0742
8·37	1·0742	37·60	1·0728
17·00	1·0770	47·00	1·0658
23·00	1·0791	50·00	1·0637
28·10	1·0763	51·80	1 063

Acetic acid readily takes fire when it is heated in open vessels to the boiling point, and it burns with a blue flame, nearly like alcohol. It must be kept in close vessels, otherwise it loses its strength, by attracting humidity from the air. When concentrated, it is used only as a scent, or pungent exciter of the olfactory organs, in sickness and fainting fits. Its anti-epidemic qualities are apocryphal. What is met with in the shops under the name of salts of vinegar is nothing but sulphate of potash, put up in small vials, and impregnated with acetic acid, sometimes rendered aromatic with oil of rosemary or lavender.

Acetic acid, in its dry state, as it exists in fused acetate of potash or soda, is composed of

$$
\begin{array}{l}
47\cdot536 \text{ carbon} \\
5\cdot822 \text{ hydrogen} \\
46\cdot642 \text{ oxygen} \\
\hline
100\cdot000
\end{array}
$$

And its symbol by Berzelius is $H^6 C^4 O^3 = A$. We must bear in mind that his atomic weight for hydrogen is only one half of the number usually assigned to it by British chemists, in consequence of his making water a compound of two atoms of hydrogen and one of oxygen.

When the vapor of acetic acid is made to traverse a red-hot tube of iron, it is converted into water, carbonic acid, carbureted hydrogen, but chiefly pyro-acetic spirit.

Acetic acid is a solvent of several organic products; such as camphor, gluten, gum-resins, resins, the fibrine of blood, the white of egg, &c.

It is an important problem to ascertain the purity and strength of vinegar. Spurious acidity is too often given to it by cheaper acids, such as the sulphuric and the nitric. The former may most surely be detected by the nitrate of baryta, or even by acetate of lead, which occasion a white precipitate in such adulterated vinegar. For the case of nitric, which is more insidious, the proper test is, a bit of gold leaf, wetted with a few drops of muriatic acid. If the leaf dissolves, on heating the mixture in a watch glass, we may be sure that nitric acid is present.

Specific gravity, if determined by a sensible hydrometer, is a good test of the strength of the genuine vinegar; and the following table of Messrs. Taylor is nearly correct, or sufficiently so for commercial transactions.

Revenue proof vinegar, called by the English manufacturer No. 24, has a specific gravity of

1·0085 and contains of real acid in 100—	5
1·0170 - - - - - - - -	10
1·0257 - - - - - - - -	15
1·0320 - - - - - - - -	20
1·0470 - - - - - - - -	30
1·0580 - - - - - - - -	40

As excise duty of 2d. is levied on every gallon of the above proof vinegar. Its strength is not, however, estimated directly by its specific gravity, but by the specific gravity which it assumes when saturated with quicklime. The decimal fraction of the specific gravity of the calcareous acetate is very nearly the double of that of the pure vinegar; or, 1·009 in vinegar becomes 1·018 in acetate of lime. The vinegar of malt contains so much mucilage or gluten, that when it has only the same acid strength as the above, it has a density of 1.0014, but it becomes only 1·023 when converted into acetate of lime: indeed, 0·005 of its density is due to mucilaginous matter. This fact shows the fallacy of trusting to the hydrometer for determining the strength of vinegars, which may be more or less loaded with vegetable gluten. The proper test of this, as of all other acids, is, the quantity of alkaline matter which a given weight or measure of it will saturate. For this purpose the bicarbonate of potash, commonly called, in the London shops, carbonate, may be employed very conveniently. As it is a very uniform substance, and its atomic weight, by the hydrogen radix, is 100·584, while the atomic weight of acetic acid, by the same radix, is 51·563, if we estimate 2 grains of the bicarbonate as equivalent to 1 of the real acid, we shall commit no appreciable error. Hence, a solution of the carbonate containing 200 grains in 100 measures, will form an acetimeter of the most perfect and convenient kind; for the measures of test liquid expended in saturating any measure,—for instance, an ounce or 1000 grains of acid,—will indicate the number of grains of real acetic acid in that quantity. Thus, 1000 grains of the above proof, would require 50 measures of the acetimetrical alkaline solution, showing that it contains 50 grains of real acetic acid in 1000, or 5 per cent.

It is common to add to purified wood vinegar, a little acetic ether, or caramelized (burnt) sugar to color it, also, in France, even wine, to flavor it. Its blanching effect upon red cabbage, which it has been employed to pickle, is owing to a little sulphurous acid. This may be removed by redistillation with peroxyde of manganese. Indeed, Stolze professes to purify the pyroligneous acid solely by distilling it with peroxyde of manganese, and then digesting it with bruised wood charcoal; or by distilling it with a mixture of sulphuric acid and manganese. But much acid is lost in this case by the formation of acetate of that metal.

Birch and beech afford most pyroligneous acid, and pine the least. It is exclusively employed in the arts, for most purposes of which it need not be very highly purified. It is much used in calico printing, for preparing acetate of iron called Iron Liquor, and acetate of alumina, called Red Liquor; which see. It serves also to make sugar of lead; yet when it contains its usual quantity, after rectification of tarry matter, the acetate of lead will hardly crystallize, but forms cauliflower concretions. This evil may be remedied, I believe, by boiling the saline solution with a very little nitric acid, which causes the precipitation of a brown granular substance, and gives the liquor a reddish tinge. The solution being afterwards treated with bruised charcoal, becomes colorless, and furnishes regular crystals of acetate or sugar of lead.

Pyroligneous acid possesses, in a very eminent degree, anti-putrescent properties. Flesh steeped in it for a few hours may be afterwards dried in the air without corrupting; but it becomes hard, and somewhat leather-like: so that this mode of preservation does not answer well for butcher's meat. Fish are sometimes cured with it. See PYRO-ACETIC ETHER; PYROXILIC ETHER; PYROXOLIC SPIRIT; PYROLIGNEOUS ACID and VINEGAR.

ACETIMETER. An apparatus for determining the strength of vinegar. See the conclusion of the preceding article for a description of my simple method of acetimetry. —

ACETONE. The new chemical name of pyro-acetic spirit.

ACID OF ARSENIC. (*Acide Arsenique*, Fr.; *Arseniksaure*, Germ.)

ACIDS. A class of chemical substances characterized by the property of combining with and neutralizing the alkaline and other bases, and of thereby forming a peculiar class of bodies called salts. The acids which constitute objects of special manufacture for commercial purposes are the following:—acetic, arsenious, carbonic, chromic, citric, malic, muriatic, nitric, oxalic, phosphoric, sulphuric, tartaric, which see.

ACROSPIRE. (*Plumule*, Fr.; *Blattkeim*, Germ.) That part of a germinating seed which botanists call the plumula, or plumes. See BEER and MALT.

ADDITIONS. Such articles as are added to the fermenting wash of the distiller are distinguished by this trivial name.

ADIPOCIRE. Fr. (*Fettwachs*, Germ.) The fatty matter generated in dead bodies buried under peculiar circumstances. In 1786 and 1787, when the churchyard of the *Innocents*, at Paris, was cleaned out, and the bones transported to the catacombs, it was discovered that not a few of the *cadavres* were converted into a saponaceous white substance, more especially many of those which had been interred for fifteen years in one pit, to the amount of 1500, in coffins closely packed together. These bodies were flattened, in consequence of their mutual pressure; and, though they generally retained their shape, there was deposited round the bones of several a grayish white, somewhat soft, flexible substance. Fourcroy presented to the Academy of Sciences, in 1789, a comprehensive memoir upon this phenomenon, which appeared to prove that the fatty body was an ammoniacal soap, containing phosphate of lime; that the fat was similar to spermaceti, as it assumed on slow cooling a foliated crystalline structure; as also to wax, as, when rapidly cooled, it became granular: hence he called it *Adipocire*. Its melting point was 52·5° C. (126·5° Fahr.). He likewise compared this soap to the fat of gall-stones, and supposed it to be a natural product of the slow decomposition of all animal matter, except bones, nails, and hairs.

This substance was again examined by Chevreul in 1812, and was found by him to contain margaric acid, oleic acid, combined with a yellow coloring, odorous matter, besides ammonia, a little lime, potash, oxyde of iron, salts of lactic acid, an azotized substance; and was therefore considered as a combination of margaric and oleic acids, in variable proportions (whence arose its variable fusibility), but that it was not analogous with either spermaceti or cholesterine (gallstones). These fat acids are obviously generated by the reaction of the ammonia upon the margarine and oleine, though they eventually lose the greater part of that volatile alkali.

According to the views of both Gay Lussac and Chevreul, this *adipocire* proceeds solely from the pre-existing fat of the dead body, and not from the flesh, tendons, or cartilages, as had been previously imagined; which had led to some expensive and abortive attempts, upon the great scale of manufacture, to convert the dead bodies of cattle into adipocire, for the purposes of the candle-maker or soap-boiler, by exposing them for some time to the action of moisture.

Von Hartkol made experiments during 25 years upon this subject, from which he inferred, that there is no formation of adipocire in bodies buried in dry ground; that in moist earth the fat of the dead body does not increase, but changes into a fetid saponaceous substance, incapable of being worked into either soap or candles; that the dead bodies of *mammalia* immersed in running water, leave behind after 3 years a pure fat, which is more abundant from young than from old anmials; that the intestines afford more fat than the muscles; that from this fat, without any purification, candles may be made, as void of smell, as hard, and as white, as from bleached wax; that from cadavers immersed for 3 years in stagnant water, more fat is procured than from those in running water, but that it needs to be purified before it can be made into soap or candles.

The cause of the difference between Hartkol's and Chevreul's results cannot be assigned, as the latter has not published his promised remarks upon the subject. At any rate, dead animal matter can be worked up more profitably than in making artificial adipocire.

ADIT. The horizontal entrance of a mine. It is sometimes called the drift. See MINING and METALLURGY.

ADULTERATION. The debasing any product of manufacture, especially chemical, by the introduction of cheap materials. The art of ascertaining the genuineness of the several products will be taught under the specific objects of manufacture.

ÆTHER. See ETHER.

AFFINITY. The chemical term denoting the peculiar attractive force which produces the combination of dissimilar substances; such as of an alkali with an acid, or of sulphur with a metal.

AGARIC. A species of boletus or fungus, which grows in dunghills; with the salts of iron it affords a black dye. It is said to be convertible into a kind of china ink.

AGATE. A silicious mineral which is cut into seals and other forms for the coarser kinds of jewellery. See GEM.

AIR. See VENTILATION.

ALABASTER, is a stone usually white, and soft enough to be scratched by iron. There are two kinds of it : the gypseous, which is merely a natural semi-crystalline sulphate of lime ; and the calcareous alabaster, which is a carbonate of lime. The oriental alabaster is always of the latter kind, and is most esteemed, because it is agreeably variegated with lively colors, and especially with zones of honey-yellow, yellow-brown, red, &c. ; it is, moreover, susceptible of taking a marble polish.

The fineness of the grain of alabaster, the uniformity of its texture, the beauty of its polished surface, and its semi-transparency, are the qualities which render it valuable to the sculptor and to the manufacturer of ornamental toys.

The limestone alabaster is frequently found as a yellowish-white deposite in certain fountains. The most celebrated spring of this kind is that of the baths of San Filippo, in Tuscany. The water, almost boiling hot, runs over an enormous mass of stalactites, which it has formed, and holds the carbonate of lime in solution by means of sulphureted hydrogen (according to M. Alexandre Brongniard), which escapes by contact of the atmosphere. Advantage has been taken of this property to make *basso relievos* of considerable hardness, by placing moulds of sulphur very obliquely, or almost upright, in wooden tubs open at the bottom. These tubs are surmounted at the top with a large wooden cross. The water of the spring, after having deposited in an external conduit or cistern the coarser sediment, is made to flow upon this wooden cross, where it is scattered into little streamlets, and thence lets fall, upon the sulphur casts, a precipitate so much the finer the more nearly vertical the mould. From one to four months are required for this operation, according to the thickness of the deposited crust. By analogous processes, the artists have succeeded in moulding vases, figures of animals, and other objects, in relief, of every different form, which require only to be trimmed a little, and afterwards polished.

The common alabaster is composed of sulphuric acid and lime, though some kinds of it effervesce with acids, and therefore contain some carbonate of lime. This alabaster occurs in many different colors, and of very different degrees of hardness, but it is always softer than marble. It forms, usually, the lowest beds of the gypsum quarries. The sculptors prefer the hardest, the whitest, and those of a granular texture, like Carrara marble, and so like that they can only be distinguished by the hardness.

The alabaster is worked with the same tools as marble; and as it is many degrees softer, it is so much the more easily cut; but it is more difficult to polish, from its little solidity. After it has been fashioned into the desired form, and smoothed down with pumice stone, it is polished with a pap-like mixture of chalk, soap, and milk; and, last of all, finished by friction with flannel. It is apt to acquire a yellowish tinge.

Besides the harder kinds, employed for the sculpture of large figures, there is a softer alabaster, pure white and semi-transparent, from which small ornamental objects are made, such as boxes, vases, lamps, stands of time-pieces, &c. This branch of business is much prosecuted in Florence, Leghorn, Milan, &c., and employs a great many turning lathes. Of all the alabasters, the Florentine merits the preference, on account of its beauty and uniformity, so that it may be fashioned into figures of considerable size : for which purpose there are large work-shops where it is cut with steel saws into blocks and masses of various shapes. Other sorts of gypsum, such as that of Salzburg and Austria, contain sand veins, and hard nodules, and require to be quarried by cleaving and blasting operations, which are apt to crack it, and unfit it for all delicate objects of sculpture. It is, besides, of a gray shade, and often stained with darker colors.

The alabaster best adapted for the fine arts is pretty white when newly broken, and becomes whiter on the surface by drying. It may be easily cut with the knife or chisel, and formed into many pleasing shapes by suitable steel tools. It is worked either by the hand alone, or with the aid of a turning lathe. The turning tools should not be too thin or sharp-edged; but such as are employed for ivory and brass are most suitable for alabaster, and are chiefly used to shave and to scratch the surface. The objects which cannot be turned may be fashioned by the rasping tools, or with minute files, such as variegated foliage. Fine chisels and graving tools are also used for the better pieces of statuary.

For polishing such works, a peculiar process is required : pumice stone, in fine powder, serves to smooth down the surfaces very well, but it soils the whiteness of the alabaster. To take away the unevennesses and roughnesses dried shave-grass (*equisetum*) answers best. Frictions with this plant and water polish down the asperities left by the chisel : the fine streaks left by the grass may be removed by rubbing the pieces with slaked lime, finely pulverized and sifted, made into a paste, or putty, with water. The

polish and satin-lustre of the surface are communicated by friction, first with soap-water and lime, and finally with powdered and elutriated talc or French chalk.

Such articles as consist of several pieces are joined by a cement composed of quicklime and white of egg, or of well-calcined and well-sifted Paris plaster, mixed with the least possible quantity of water.

Alabaster objects are liable to become yellow by keeping, and are especially injured by smoke, dust, &c. They may be in some measure restored by washing with soap and water, then with clear water, and again polished with shave-grass. Grease spots may be removed either by rubbing with talc powder, or with oil of turpentine.

The surface of alabaster may be etched by covering over the parts that are not to be touched with a solution of wax in oil of turpentine, thickened with white lead, and immersing the articles in pure water after the varnish has set. The action of the water is continued from 20 to 50 hours, more or less, according to the depth to which the etching is to be cut. After removing the varnish with oil of turpentine, the etched places, which are necessarily deprived of their polish, should be rubbed with a brush dipped in finely-powdered gypsum, which gives a kind of opacity, contrasting well with the rest of the surface.

Alabaster may be stained either with metallic solutions, with spirituous tinctures of dyeing plants, or with colored oils, in the same way as marbles.

This substance has been hardened, it is said, by exposing it to the heat of a baker's oven for 10 or 20 hours, after taking it out of the quarry, and giving it the figure, roughly, which it is intended to have. After this exposure, it must be dipped for two minutes in running water; when it is cold, it must be dipped a second time for the same period. On being exposed to the air for a few days, alabaster so treated acquires a marble-like hardness. I doubt the truth of this statement.

ALBUM GRÆCUM. The white dung of dogs, sometimes used to soften leather in the process of dressing it after the depilatory action of lime.

ALCARAZZAS. A species of porous earthenware, made in Spain, for cooling liquors. See POTTERY.

ALCOHOL. The well-known intoxicating liquor procured by distillation from various vegetable juices, and infusions of a saccharine nature, which have undergone the vinous fermentation. Common alcohol, or proof spirit, as it is called, contains about one half its weight of water. It may be concentrated till its specific gravity becomes so low as 0·825, by simple redistillation at a steam or water-bath heat; but to make it stronger, we must mix with it, in the still or retort, dry carbonate of potash, muriate of lime, or some other substances strongly attractive of water, and then it may be obtained of a specific gravity so low as 0·791 at 16° Reaumur (68° Fahr.), water being 1·000. At 0·825, it contains, still, 11 per cent. of water; and in this state it is as volatile as absolute alcohol, on account of the inferior density of the aqueous vapor, compared to the alcoholic. Indeed, according to Yelin and Fuchs, the boiling point of anhydrous alcohol is higher than of that which contains 2 or 3 per cent. of water; hence, in the distillation of alcohol of 94 per cent., the first portions that come over are more aqueous than the following. Absolute alcohol has its boiling point at 168¼° Fahr.; but when it holds more than 6 per cent. of water, the first portions that come over are richest in alcohol, and the temperature of the boiling point, or of the spirituous vapor, is always higher the longer the distillation continues. According to Gröning's researches, the following temperatures of the alcoholic vapors correspond to the accompanying contents of alcohol in per centage of volume, which are disengaged in the boiling of the spirituous liquid.

Temperature.	Alcoholic content of the vapor.	Alcoholic content of the boiling liquid.	Temperature.	Alcoholic content of the vapor.	Alcoholic content of the boiling liquid.
Fahr. 170 ·0	93	92	Fahr. 189 ·8	71	20
171 ·8	92	90	192 ·0	68	18
172	91	85	164	66	15
172 ·8	90¼	80	196 ·4	61	12
174	90	70	198 ·6	55	10
174 ·6	89	70	201	50	7
176	87	65	203	42	5
178 ·3	85	50	205 ·4	36	3
180 ·8	82	40	207 ·7	28	2
183	80	35	210	13	1
185	78	30	212	0	0
187 ·4	76	25			

Gröing undertook this investigation in order to employ the thermometer as an alco-holmeter in the distillation of spirits; for which purpose he thrust the bulb of the ther-mometer through a cork, inserted into a tube fixed in the capital of the still. The state of the barometer ought also to be considered in making comparative experiments of this kind. Since, by this method, the alcoholic content may be compared with the tempera-ture of the vapor that passes over at any time, so, also, the contents of the whole distil-lation may be found approximately; and the method serves as a convenient means of making continual observations on the progress of the distillation.

The temperature, corresponding to a certain per centage of alcohol in vapor, suggests the employment of a convenient method for obtaining, at one process, a spirit as free from water as it can be made by mere distillation. We place over the top of the capital a water-bath, and lead up through it a spiral pipe from the still, which there passes oblique-ly downwards, and proceeds to the refrigeratory. If this bath be maintained, by a constant influx of cold water, at a certain temperature, only the alcoholic vapor corresponding to that temperature will pass over, and the rest will be recondensed and returned into the still. If we keep the temperature of the water at 174°, for example. the spirituous va-por which passes over will contain 90 per cent. of absolute alcohol, according to the preceding table. The skilful use of this principle constitutes the main improvement in modern distilleries. See DISTILLATION and STILL.

Another method for concentrating alcohol is that discovered by Sömmering, founded upon the property of ox bladders to allow water to pass through and evaporate out of them, but not to permit alcohol to transpire, or only in a slight degree. Hence, if an ox's bladder is filled with spirit of wine, well tied at the mouth, and suspended in a warm place, the water will continually exhale, and the alcohol will become nearly anhydrous; for in this way alcohol of 97 or 98 per cent. may be obtained.

According to Sömmering, we should take for this purpose the bladder of an ox or a calf, soak it for some time in water, then inflate it and free it from the fat and the attached vessels; which is to be also done to the other surface, by turning it inside out. After it is again inflated and dried, we must smear over the outer side twice, and the inner side four times, with a solution of isinglass, by which its texture is made closer, and the concen-tration of the alcohol goes on better. A bladder so prepared may serve more than a hundred times. It must be charged with the spirits to be concentrated, leaving a small space vacant; it is then to be tightly bound at the mouth, and suspended in a warm situation, at a temperature of 122° Fahr, over a sand-bath, or in the neighborhood of an oven. The surface of the bladder remains moist with the water, as long as the sp. gr. of the contained spirit is greater than 0·952. Weak spirit loses its water quicker than strong; but in ·from 6 to 12 hours the alcohol may be concentrated, when a suitable heat is em-ployed. This economical method is particularly applicable in obtaining alcohol for the preparation of varnishes. When the alcohol is to serve for other purposes, it must be freed, by distillation, from certain matters dissolved out of the bladder. Alcohol may likewise be strengthened, as Sömmering has ascertained, when the vessel that contains the spirit is bound over with a bladder which does not come into contact with the liquid. Thus, too, all other liquors containing alcohol and water, as wine, cider, &c., may be made more spirituous.

To procure absolute alcohol, we must take chloride of calcium recently fused, reduce it to coarse powder, and mix it with its own weight of spirit of wine, of sp. gr. 0·833, in a bottle, which is to be well stoppered, and to be agitated till the salt is dissolved. The clear solution is to be poured into a retort, and half of the volume of the alcohol employed, or so much as has the sp. gr. 0·791 at 68° Fahr., is to be distilled off at a gentle heat. Quicklime has also been employed for the same purpose, but it is less powerful and convenient. Alcohol, nearly free from water, may be obtained without distillation, by adding dry carbonate of potash to a spirit of wine, of sp. gr. 0·825. The water combines with the potash, and falls to the bottom in a dense liquid, while the pure spirit floats on the surface. This contains, however, a little alkali, which can only be separated by distillation.

Anhydrous alcohol is composed by weight of 52·66 carbon, 12·90 hydrogen. and 34·44 of oxygen. It has a very powerful attraction for water, and absorbs it from the atmos-phere; therefore it must be kept in well-closed vessels. It also robs vegetable and ani-mal bodies of their moisture; and hence common alcohol is employed for preserving ana-tomical preparations. Alcohol is a solvent for many substances: resins, essential oils, camphor, are abundantly dissolved by it, forming varnishes, perfumed spirits, &c. The solution of a resin or essential oil in alcohol becomes milky on the addition of water, which, by its attraction for alcohol, separates these substances. Several salts, especially the deliquescent, are dissolved by it, and some of them give a color to its flame; thus, the solutions of the salts of strontia in alcohol burn with a crimson flame, those of cop-per and borax green, lime reddish. and baryta yellow.

When water is mixed with alcohol, heat and a condensation of volume are the result;

these effects being greatest with 54 per cent. of alcohol and 46 of water, and thence i creasing with a greater proportion of water. For alcohol which contains 90 per ce of water, this condensation amounts to 1·94 per cent. of the volume; for 80 per cei 2·87; for 70 per cent., 3·44; for 60 per cent., 3·73; for 40 per cent., 3·44; for 30 | cent., 2·72; for 20 per cent., 1·72; for 10 per cent., 0·72. Hence, to estimate i quantity of alcohol in any spirit it is necessary that the specific gravity be ascertair for each determinate proportion of alcohol and water that are mixed together. Wl this is done, we may, by means of an areometer constructed for liquids lighter tl water, determine the strength of the spirit, either by a scale of specific gravities or by arbitrary graduation corresponding to certain commercial objects, and thus we may i termine the per centage of alcohol in whiskey or brandy of any strength or purity. areometer intended for this use has been called an alcoholmeter, in particular when scale of it is so graduated that, instead of the specific gravity, it indicates immediat the per centage of anhydrous alcohol in a given weight or volume of the liquid. 1 scale graduated according to the per centage of pure alcohol by weight, constitutes alcoholmeter of Richter; and that by the per centage in volume, the alcoholmeter Tralles and Gay Lussac.

As liquors are sold in general by the measure, not by the weight, it is convenie therefore, to know the alcoholic content of the mixtures in the per centage by volui Tralles has constructed new tables upon the principles of those of Gilpin, in which i proportion is given by volume, and anhydrous alcohol is assumed for the basis; whi at 60° Fahr., has a specific gravity of 0·7939 compared with water at its maxim density, or a specific gravity of 0·7946 compared with water of the temperature of (Fahr. Gilpin's alcohol of 0·825 contains 92·6 per cent. by volume of anhydrous alcoh

The following table exhibits the per centage of anhydrous alcohol by volume, a temperature of 60° Fahr., in correspondence with the specific gravities of the spir water being considered at 60° Fahr. to have a specific gravity of 0·9991.

Alcoholmetrical Table of Tralles.

Alcohol in 100 measures of spirit.	Specific gravity at 60° Fahr.	Difference of the sp. gr.	Alcohol in 100 measures of spirit.	Specific gravity at 60° Fahr.	Difference the sp. gr.
0	9991		51	9315	20
1	9976	15	52	9295	20
2	9961	15	53	9275	20
3	9947	14	54	9254	21
4	9933	14	55	9234	20
5	9919	14	56	9213	21
6	9906	13	57	9192	21
7	9893	13	58	9170	22
8	9881	12	59	914S	22
9	9869	12	60	9126	22
10	9857	12	61	9104	22
11	9845	12	62	9082	22
12	9834	11	63	9059	23
13	9823	11	64	9036	23
14	9812	11	65	9013	23
15	9802	10	66	8989	24
16	9791	11	67	8965	24
17	9781	10	68	8941	24
18	9771	10	69	8917	24
19	9761	10	70	8892	25
20	9751	10	71	8867	25
21	9741	10	72	8842	25
22	9731	10	73	8817	25
23	9720	11	74	8791	26
24	9710	10	75	8765	26
25	9700	10	76	8739	26
26	9689	11	77	8712	27
27	9679	10	78	8685	27
28	9668	11	79	8658	27
29	9657	11	80	8631	27
30	9646	11	81	8603	28
31	9634	12	82	8575	28
32	9622	12	83	8547	2S
33	9609	13	84	8518	29

Alcoholmetrical Table of Tralles (continued).

Alcohol in 100 measures of spirit.	Specific gravity at 60° Fahr.	Difference of the sp. gr.	Alcohol in 100 measures of spirit.	Specific gravity at 60° Fahr.	Difference of the sp. gr.
34	9596	13	85	8488	30
35	9583	13	86	8458	30
36	9570	13	87	8428	30
37	9556	14	88	8397	31
38	9541	15	89	8365	32
39	9526	15	90	8332	33
40	9510	16	91	8299	33
41	9494	16	92	8265	34
42	9478	16	93	8230	35
43	9461	17	94	8194	36
44	9444	17	95	8157	37
45	9427	17	96	8118	39
46	9409	18	97	8077	41
47	9391	18	98	8034	43
48	9373	18	99	7988	46
49	9354	19	100	7939	49
50	9335	19			

Remarks on the preceding Table of Alcohol.

The third column of this table exhibits the differences of the specific gravities, which give the denominator of the fraction for such densities as are not found sufficiently near in the table; and the difference of their numerators is the next greatest to the density found in the table. For example: if the specific gravity of the liquor found for 60° Fahr. = 9605·(the per centage will be between 33 and 34), the difference from 9609 (which is the next greatest number in the table) = 4, and the fraction is $\frac{4}{13}$. therefore the true per centage is $33\frac{4}{13}$. From the construction of this table the per centage of alcohol by weight may also be found. For instance: we multiply the number representing the *volumes* of alcohol (given in the table for any determinate specific gravity of the mixture) by the specific gravity of the pure alcohol, that is, by 7939, and the product is the number of pounds of alcohol in so many pounds as the specific gravity multiplied by 100 gives. Thus, in the mixture of 9510 specific gravity, there are 40 measures of alcohol; hence there are also in 95,100 pounds of this spirit 7939 + 40 = 31·756 pounds of alcohol; and in 100 pounds of the spirits of 0·9510 specific gravity, 33·39 pounds of alcohol are contained.

As the preceding table gives the true alcoholic content when the portion of spirit under trial has the normal temperature of 60° Fahr., the following table gives the per centage of alcohol for the specific gravities corresponding to the accompanying temperatures.

For example: if we have a spirituous liquor at 80° Fahr., whose specific gravity is 0·9342, the alcohol present is 45 per cent. of the volume, or that specific gravity at that temperature is equal to the specific gravity 0·9427 at the normal temperature of 60° Fahr. This table may also be employed for every degree of the thermometer and

Alcohol per cent.	Temperature.						Alcohol per cent.	Temperature.					
	30° F.	35° F.	40° F.	45° F.	50° F.	55° F.		60° F.	65° F.	70° F.	75° F.	80° F.	85° F.
0	9994	9997	9997	9998	9997	9994	0	9991	9987	9991	9976	9970	9962
5	9934	9938	9926	9926	9925	9923	5	9919	9915	9909	9903	9897	9890
10	9864	9860	9868	9467	9865	9861	10	9857	9852	9845	9839	9831	9825
15	9423	9422	9420	9417	9313	9407	15	9802	9796	9788	9779	9771	9761
20	9784	9782	9777	9773	9766	9759	20	9751	9742	9733	9722	9711	9700
25	9752	9748	9738	9739	9726	9709	25	9700	9690	9678	9665	9652	9628
30	9717	9707	9695	9684	9672	9659	30	9646	9632	9618	9603	9588	9572
35	9671	9658	9644	9629	9614	9599	35	9583	9566	9549	9532	9514	9495
40	9615	9598	9581	9563	9546	9528	40	9510	9491	9472	9452	9433	9412
45	9544	9525	9506	9486	9467	9447	45	9427	9406	9385	9364	9342	9320
50	9460	9440	9420	9399	9378	9356	50	9335	9313	9290	9267	9244	9221
55	9368	9347	9325	9302	9279	9256	55	9234	9211	9187	9163	9139	9114
60	9267	9245	9222	9199	9174	9150	60	9126	9102	9076	9051	9026	9000
65	9162	9138	9113	9088	9003	9018	65	9013	8988	8962	8936	8909	8882
70	9046	9021	8996	8970	8944	8917	70	8892	8866	8839	8812	8784	8756
75	8925	8899	8873	8847	8820	8793	75	8765	8738	8710	8681	8652	8622
80	8798	8771	8744	8716	8688	8659	80	8631	8602	8573	8544	8514	8483
85	8663	8635	8606	8577	8547	8517	85	8488	8458	8427	8396	8365	8333
90	8517	8486	8455	8425	8395	8363	90	8332	8300	8268	8236	8204	8171

every per centage, so as to save computation for the intervals. It is evident from in-spection that a difference of 5° Fahr. in the temperature changes the specific gravity of the liquor by a difference nearly equal to 1 volume per cent. of alcohol; thus at 35° and 85° Fahr. the very same specific gravity of the liquor shows nearly 10 volumes per cent. of alcohol more or less; the same, for example, at 60 and 40 per cent.

The importance of extreme accuracy in determining the density of alcoholic mixtures in the United Kingdom, on account of the great revenue derived from them to the State, and their consequent high price in commerce, induced the Lords of the Treasury a few years ago to request the Royal Society to examine the construction and mode of applying the instrument now in use for ascertaining and charging the duty on spirits. This instru-ment, which is known and described in the law as Sikes's hydrometer, possesses, in many respects, decided advantages over those formerly in use. The committee of the Royal Society state, that a definite mixture of alcohol and water is as invariable in its value as absolute alcohol can be; and can be more readily, and with equal accuracy, identified by that only quality or condition to which recourse can be had in practice, namely, specific gravity. The committee further proposed, that the standard spirit be that which, consisting of alcohol and water alone, shall have a specific gravity of 0·92 at the temperature of 62° Fahr., water being unity at the same temperature; or, in other words, that it shall at 62° weigh $\frac{92}{100}$ or $\frac{23}{25}$ of an equal bulk of water at the same temperature.

This standard is rather weaker than the old proof, which was $\frac{12}{13}$, or 0·923; or in the proportion of nearly 1·1 gallon of the present proof spirit per cent. The proposed standard will contain nearly one half by weight of absolute alcohol. The hydrometer ought to be so graduated as to give the indication of strength; not upon an arbitrary scale, but in terms of specific gravity at the temperature of 62°.

The committee recommend the construction of an equation table, which shall indicate the same strength of spirit at every temperature. Thus in standard spirit at 62° the hydrometer would indicate 920, which in this table would give proof spirit. If that same spirit were cooled to 40°, the hydrometer would indicate some higher number; but which, being combined in the table with the temperature as indicated by the thermometer, should still give proof or standard spirit as the result.

It is considered advisable, in this and the other tables, not to express the quality of the spirit by any number over or under proof, but to indicate at once the number of gallons of standard spirit contained in, or equivalent to, 100 gallons of the spirit under examination. Thus, instead of saying 23 over proof, it is proposed to insert 123; and in place of 35·4 under proof, to insert its difference to 100, or 64·6.

It has been considered expedient to recommend a second table to be constructed, so as to show the bulk of spirit of any strength at any temperature, relative to a standard bulk of 100 gallons at 62°. In this table a spirit which had diminished in volume, at any given temperature, 0·7 per cent., for example, would be expressed by 99·3; and a spirit which had increased at any given temperature 0·7 per cent., by 100·7.

When a sample of spirit, therefore, has been examined by the hydrometer and thermometer, these tables will give first the proportion of standard spirit at the observed temperature, and next the change of bulk of such spirit from what it would be at the standard temperature. Thus, at the temperature of 51°, and with an indication (sp. gr.) of 8240, 100 gallons of the spirit under examination would be shown by the first table to be equal to 164·8 gallons of standard spirit of that temperature; and by the second table it would appear that 99·3 gallons of the same spirit would become 100 at 62°, or in reality contain the 164·8 gallons of spirit in that state only in which it is to be taxed.

But as it is considered that neither of these tables can alone be used for charging the duty (for neither can express the actual quantity of spirit of a specific gravity of 0·92 at 62° in 100 gallons of stronger or weaker spirit at temperatures above or below 62°), it is considered essential to have a third table, combining the two former, and expressing this relation directly, so that upon mere inspection it shall indicate the proportion of standard spirit in 100 gallons of that under examination in its then present state. In this table the quantities should be set down in the actual number of gallons of standard spirit at 62°, equivalent to 100 of the spirit under examination; and the column of quantities may be expressed by the term *value*, as it in reality expresses the proportion of the only valuable substance present. As this will be the only table absolutely necessary to be used with the instrument for the purposes of the excise, it may, perhaps, be thought unnecessary to print the former two.

The following specimen table has been given by the committee :—

Temperature 45°.			Temperature 75°.		
Indication.*	Strength.	Value.	Indication.	Strength.	Value.
9074	114·5		8941	114·5	
7	114·3		4	114·3	
9	114·2		5	114·2	
81	114·0		8	114·0	
3	113·9		9	113·9	
5	113·7		52	113·7	
6	· 113·6		3	113·6	
9	113·4		6	113·4	
90	113·3		7	113·3	
3	113·1		9	113·1	

The mixture of alcohol and water, taken as spirit in Mr. Gilpin's tables, is that of which the specific gravity is 0·825 at 60° Fahr., water being unity at the same temperature. The specific gravity of water at 60° being 1000, at 62° it is 99,981. Hence, in order to compare the specific gravities given by Mr. Gilpin with those which would result when the specific gravity of water at 62° is taken at unity, all the former numbers must be divided by 99,981.

Table of the Specific Gravities of different Mixtures, by Weight, of Alcohol and Water, at different Temperatures; constructed by Mr. Gilpin, for the use of the British Revenue on Spirits.

Temperature, Fahr.	Pure Alcohol	100 Alcohol 5 Water.	100 Alcohol 10 Water.	100 Alcohol 15 Water.	100 Alcohol 20 Water.	100 Alcohol 25 Water.	100 Alcohol 30 Water.	100 Alcohol 35 Water.	100 Alcohol 40 Water.	100 Alcohol 45 Water.	100 Alcohol 50 Water.
Deg.											
30	0·83896	0·84995	0·85957	0·86625	0·87585	0·88282	0·88921	0·89511	0·90054	0·90558	0·91023
35	·83672	·84769	·85729	·86587	·87357	·88059	·88701	·89294	·89839	·90345	·90811
40	·83445	·84539	·85507	·86361	·87184	·87838	·88481	·89073	·89617	·90127	·90596
45	·83214	·84310	·85277	·86131	·86905	·87613	·88255	·88849	·89396	·89909	·90380
50	·82977	·84076	·85042	·85902	·86676	·87384	·88030	·88626	·89174	·89684	·90160
55	·82736	·83834	·84802	·85664	·86441	·87150	·87796	·88393	·88945	·89458	·89932
60	·82500	·83599	·84568	·85430	·86208	·86918	·87569	·88169	·88720	·89232	·89707
65	·82262	·83362	·84334	·85193	·85976	·86686	·87337	·87938	·88490	·89006	·89479
70	·82022	·83124	·84092	·84951	·85736	·86451	·87105	·87705	·88254	·88773	·89252
75	·81780	·82878	·83851	·84710	·85496	·86212	·86864	·87466	·88018	·88538	·89018
80	·81530	·82631	·83603	·84467	·85248	·85966	·86622	·87228	·87776	·88301	·88781
85	·81291	·82396	·83371	·84243	·85036	·85757	·86411	·87021	·87590	·88120	·88609
90	·81044	·82150	·83126	·84001	·84797	·85518	·86172	·86787	87360	87889	·88376
95	·80794	·81900	·82877	·83753	·84550	·85272	·85928	·86542	·87114	·87654	·88146
100	·80548	·81657	·82639	·83513	·84038	·85031	·85688	·86302	·86879	·87421	·87915

Temperature, Fahr.	100 Alcohol 55 Water.	100 Alcohol 60 Water.	100 Alcohol 65 Water.	100 Alcohol 70 Water.	100 Alcohol 75 Water.	100 Alcohol 80 Water.	100 Alcohol 85 Water.	100 Alcohol 90 Water.	100 Alcohol 95 Water.	100 Alcohol 100 Water.
Deg.										
30	0·91449	0·91847	0·92217	0·92563	0·92889	0·93191	0·93474	0·93741	0·93991	0·94222
35	·91241	·91640	·92009	·92355	·92680	·92986	·93274	·93541	·93790	·94025
40	·91026	·91428	·91799	·92151	·92476	·92783	·93072	·93341	·93592	·93827
45	·90812	91211	·91584	·91937	·92264	·92570	·92859	93131	·93382	·93621
50	·90596	·90997	·91370	·91723	·92051	·92358	·92647	·92919	·93177	·93419
55	·90367	·90768	·91144	·91502	·91837	·92145	·92436	·92707	·92963	·93208
60	·90144	·90549	90927	·91287	·91622	·91933	·92225	·92499	·92758	·93002
65	·89920	·90328	·90707	·91066	·91400	·91715	·92010	·92293	·92546	·92794
70	·89695	·90104	·90484	·90847	·91181	·91493	·91793	·92069	·92333	·92580
75	·89464	·89872	·90252	·90617	·90952	·91270	·91569	·91849	·92111	·92364
80	·89225	·89639	·90021	·90385	·90723	·91046	·91340	·91622	·91891	·92142
85	·89043	·89460	·89843	·90200	·90558	·90882	·91186	·91465	·91729	·91960
90	·88817	·89230	·89617	·89988	·90342	·90668	·90967	·91248	·91511	·91751
95	·88588	·89003	·89390	·89763	·90119	·90443	·90747	·91029	·91290	·91531
100	·88571	·88769	·89158	·89536	·89889	·90215	·90522	·90805	·91086	·91310

* By specific gravity.

Table of the Specific Gravities of different Mixtures, &c. (*continued*).

| Temperature, Fahr.	95 Alcohol 100 Water.	90 Alcohol 100 Water.	85 Alcohol 100 Water.	80 Alcohol 100 Water.	75 Alcohol 100 Water.	70 Alcohol 100 Water.	65 Alcohol 100 Water.	60 Alcohol 100 Water.	55 Alcohol 100 Water.	50 Alcohol 100 Water.
Deg. 30	0·94447	0·94675	0·94920	0·95173	0·95429	0·95681	0·95944	0·96209	0·96470	0·96719
35	·94249	·94484	·94734	·94988	·95246	·95502	·95772	·96048	·96315	·96570
40	·94058	·94295	·94547	·94802	·95060	·95328	·95602	·95879	·96150	·96434
45	·93860	·94096	·94348	·94605	·94871	·95143	·95423	·95703	·95993	·96280
50	·93658	·93897	·94149	·94414	·94683	·94958	·95243	·95534	·95831	·96196
55	·93452	·93696	·93948	·94213	·94486	·94767	·95057	·95357	·95662	·95966
60	·93247	·93493	·93749	·94018	·94296	·94579	·94876	·95181	·95492	·95804
65	·93040	·93285	·93546	·93822	·94099	·94388	·94689	·95000	·95318	·95635
70	·92828	·93076	·93337	·93616	·93898	·94193	·94500	·94813	·95139	·95469
75	·92613	·92865	·93132	·93413	·93695	·93989	·94301	·94623	·94957	·95292
80	·92393	·92646	·92917	·93201	·93468	·93785	·94102	·94431	·94768	·95111

Temperature, Fahr.	45 Alcohol 100 Water.	40 Alcohol 100 Water.	35 Alcohol 100 Water.	30 Alcohol 100 Water.	25 Alcohol 100 Water.	20 Alcohol 100 Water.	15 Alcohol 100 Water.	10 Alcohol 100 Water.	5 Alcohol 100 Water.
Degrees. 30	0·96967	0·97200	0·97418	0·97635	0·97860	0·98108	0·98412	0·98804	0·99334
35	·96840	·97086	·97319	·97556	·97801	·98076	·98397	·98804	·99344
40	·96706	·96967	·97220	·97472	·97737	·98033	·98373	·98795	·99345
45	·96563	·96840	·97110	·97384	·97666	·97980	·98338	·98774	·99338
50	·96420	·96708	·96995	·97284	·97580	·97920	·98293	·98745	·99316
55	·96272	·96575	·96877	·97181	·97506	·97847	·98239	·98702	·99284
60	·96122	·96437	·96752	·97074	·97410	·97771	·98176	·98654	·99244
65	·95962	·96288	·96620	·96950	·97309	·97688	·98106	·98594	·99194
70	·95802	·96143	·96484	·96836	·97203	·97596	·98028	·98527	·99134
75	·95638	·95987	·96344	·96708	·97066	·97495	·97943	·98454	·99066
80	·95467	·95826	·96192	·96568	·96903	·97385	·97845	·98367	·98991

Experiments were made, by direction of the committee, to verify Gilpin's tables, which showed that the error introduced in ascertaining the strength of spirits by tables founded on Gilpin's numbers must be quite insensible in the practice of the revenue. The discrepancies thus detected, on a mixture of a given strength, did not amount in any one instance to unity in the fourth place of decimals. From a careful inspection of such documents the committee are of opinion, that Gilpin's tables possess a degree of accuracy far surpassing what could be expected, and sufficiently perfect for all practical or scientific purposes.

The following table is given by Mr. Lubbock, for converting the *apparent* specific gravity, or *indication*, into true specific gravity.

Indication.	— Temperature. +												Indication.
	30°	32°	37°	42°	47°	52°	57°	62°	67°	72°	77°	80°	
·82	·00053	·00078	·00065	·00052	·00039	·00025	·00012		·00011	·00024	·00035	·00042	·82
·83	·00084	·00079	·00066	·00052	·00039	·00016	·00012		·00012	·00024	·00036	·00042	·83
·84	·00085	·00080	·00066	·00053	·00039	·00026	·00013		·00012	·00024	·00036	·00043	·84
·85	·00086	·00081	·00067	·00054	·00040	·00026	·00013		·00012	·00025	·00037	·00043	·85
·86	·00087	·00082	·00068	·00054	·00040	·00026	·00013		·00012	·00025	·00037	·00044	·86
·87	·00088	·00083	·00069	·00055	·00041	·00027	·00013		·00012	·00025	·00037	·00044	·87
·88	·00089	·00084	·00070	·00055	·00041	·00027	·00013		·00012	·00026	·00038	·00045	·88
·89	·00090	·00085	·00070	·00055	·00042	·00028	·00013		·00012	·00026	·00038	·00045	·89
·90	·00091	·00085	·00071	·00056	·00042	·00028	·00014		·00013	·00026	·00039	·00046	·90
·91	·00092	·00086	·00072	·00057	·00043	·00028	·00014		·00013	·00026	·00039	·00046	·91
·92	·00093	·00087	·00073	·00058	·00043	·00029	·00014		·00013	·00027	·00040	·00047	·92
·93	·00094	·00088	·00073	·00059	·00044	·00029	·00014		·00013	·00027	·00040	·00047	·93
·94	·00095	·00089	·00074	·00059	·00044	·00029	·00014		·00013	·00027	·00040	·00048	·94
·95	·00096	·00090	·00075	·00060	·00045	·00029	·00014		·00012	·00028	·00041	·00048	·95
·96	·00097	·00091	·00076	·00060	·00045	·00030	·00014		·00013	·00028	·00041	·00049	·96
·97	·00098	·00092	·00077	·00061	·00046	·00030	·00015		·00014	·00028	·00042	·00049	·97
·98	·00099	·00093	·00077	·00062	·00046	·00030	·00015		·00014	·00028	·00042	·00050	·98
·99	·00100	·00094	·00078	·00062	·00047	·00031	·00015		·00014	·00029	·00043	·00050	·99
·100	·00101	·00095	·00079	·00063	·00047	·00031	·00015						·100

The hydrometer constructed, under the directions of the Commissioners of Excise, by Mr. Bate, has a scale of 4 inches in length divided into 100 parts, and 9 weights. It has thus a range of 900 divisions, and expresses specific gravities at the temperature of 62° Fahr. In order to render this instrument so accurate a measurer of the specific gravity, at the standard temperature, as to involve no error of an appreciable amount, Mr. Bate has constructed the weights (which in this instrument are immersed in the fluid of different specific gravities) so that each successive weight should have an increase of bulk over the preceding weight equal to that part of the stem occupied by the scale, and an increase of weight sufficient to take the whole of the scale, and no more, down to the liquid. This àrrangement requires great accuracy of workmanship, and enhances the price of the instrument. ·But it allows of increased strength in the ball, where it is very much required, and it gives, upon inspection only, the indication (apparent specific gravity) by which the general table is to be examined and the result ascertained. Fig. 5 represents this instrument and two of its nine ballast weights. It comprehends all specific gravities between 820 and 1000. It indicates true specific gravity with almost perfect accuracy at the temperature of 62° Fahr.; but it does not exclude other instruments from being used in conjunction with tables. The latter are, in fact, independent of the instrument, and may be used with gravimeters, or any instrument affording indications by specific gravity at a given temperature.

Fig. 5.
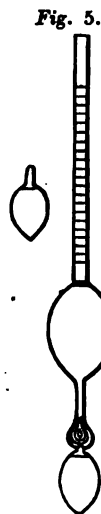
The commercial value of spirituous liquors being much lower in France than in England, a less sensible instrument becomes sufficient for the wants of that country. Baumé's and Cartier's hydrometers, with short arbitrary scales, are very much employed, but they have been lately superseded by an ingenious and ready instrument contrived by M. Gay Lussac, and called by him an *alcoomètre*. He takes for the term of comparison pure alcohol by volume, at the temperature of 15° Cent., and represents the strength of it by 100 *centimes*, or by unity. Consequently, the strength of a spirituous liquid is the number of centimes in volume of pure alcohol which that liquid contains at the temperature of 15° Cent. The instrument is formed like a common hydrometer, and is graduated for the temperature of 15° Cent. Its scale is divided into 100 parts or degrees, each of which denotes a centime of alcohol; the division 0 at the bottom of the stem corresponds to pure water, and the division 100 at its top, to pure alcohol. When immersed in a spirituous liquor at 15° Cent. (59° Fahr.) it announces its strength directly. For example : if in spirits supposed at the temperature of 15° Cent. it sinks to the division 50, it indicates that the strength of this liquor is 50 per cent., or that it contains 50 centimes of pure alcohol. In our new British proof spirit, it would sink to nearly 57, indicating 57 by volume of pure alcohol, allowing for condensation, or 50 by weight. A table of correction is given for temperature, which he calls " Table of real strength of spirituous liquors." The first vertical column of this table contains the temperatures, from 0° to 30° Cent., and the first horizontal line the indications of the alcoomètre. In the same table we have most ingeniously inserted a correction for the volume of the spirits when the temperature differs from 15° Cent. If we take 1000 litres or gallons, measured at the temperature of 2°, of a spirituous liquor whose apparent strength is 44c; its real strength at 15° will from the preceding mode of correction be 49c. On heating this liquid to 15°, in order to find its real specific gravity or strength, its bulk will become greater; and, instead of 1000 litres or gallons, which it measured at 2°, we shall have 1009 at 15° C. This number is inscribed in smaller characters in the same square cell with the real force, precisely under 49c. All the numbers in small characters, printed under each *real strength*, indicate the volume which 1000 litres of a spirituous liquor would have, when measured at the temperature at which its apparent strength is taken. In the above example, the quantity in litres or gallons of pure alcohol contained in 1000 litres or gallons of the spirits, measured at the temperature of 2°, will be, therefore,— 1009 lit. $\times$ 0·49 = 494 lit. 41.

This quantity of pure alcohol, thus estimated, is called *richness of spirit in alcohol*, or simply *richness*.

Let us take an example similar to the preceding, but at a higher temperature than 15° Cent. Suppose we have 1000 litres measured, at the temperature of 25°, of spirits whose apparent strength is 53c, what is the real quantity of pure alcohol which this spirit contains at the temperature of 15° ? We shall find in the table, first of all, that the real strength of the spirits is 49c·3. As to its bulk or volume, it is very clear that the 1000 litres in cooling from 25° to 15°, will occupy a smaller space. This volume will be 993 litres; it is inscribed directly below 49c·3, the real strength. We

shall therefore have of pure alcohol, contained in the 1000 litres of spirits, measured at the temperature of 25°, or their *richness*, 993 lit. $\times$ 0·493 = 489 lit. 55.

Alcometrical Table of real Strength, by M. Gay Lussac.

Temperature. C.	31c	32c	33c	34c	35c	36c	37c	38c	39c	40c
Deg. 10	33·0 1002	34 1002	35 1003	36 1003	37 1003	38 1003	39 1003	40 1003	41 1003	42 1003
11	32·6 1002	33·6 1002	34·6 1002	35·6 1002	36·6 1002	37·6 1002	38·6 1002	39·6 1002	40·6 1003	41·6 1003
12	32·2 1001	33·2 1001	34·2 1002	35·2 1002	36·2 1002	37·2 1002	38·2 1002	39·2 1002	40·2 1002	41·2 1002
13	31·8 1001	32·8 1001	33·8 1001	34·8 1001	35·8 1001	36·8 1001	37·8 1001	38·8 1001	39·8 1001	40·8 1001
14	31·4 1001	32·4 1001	33·4 1001	34·4 1001	35·4 1001	36·4 1001	37·4 1001	38·4 1001	39·4 1001	40·4 1001
15	31 1000	32 1000	33 1000	34 1000	35 1000	36 1000	37 1000	38 1000	39 1000	40 1000
16	30·6 1000	31·6 1000	32·5 999	33·5 999	34·5 999	35·5 999	36·5 999	37·5 999	38·5 999	39·5 999
17	30·2 999	31·2 999	32·1 999	33·1 999	34·1 999	35·1 999	36·1 999	37·1 999	38·1 999	39·1 999
18	29·8 999	30·8 999	31·7 998	32·7 998	33·7 998	34·7 998	35·7 998	36·7 998	37·7 998	38·7 998
19	29·4 998	30·4 998	31·3 998	32·3 998	33·3 998	34·3 998	35·3 998	36·3 998	37·3 997	38·3 997
20	29 998	30 998	30·9 997	31·9 997	32·9 997	33·9 997	34·9 997	35·9 997	36·9 997	37·9 997
21	28·6 997	29·6 997	30·5 997	31·5 997	32·5 997	33·5 997	34·5 997	35·5 996	36·5 996	37·5 996
22	28·2 997	29·2 997	30·1 996	31·1 996	32·1 996	33·1 996	34·1 996	35·1 996	36·1 996	37·1 996
23	27·8 996	28·8 996	29·7 996	30·7 996	31·7 996	32·7 996	33·7 996	34·7 995	35·7 995	36·7 995
24	27·4 996	28·4 996	29·3 995	30·3 995	31·3 995	32·3 995	33·3 995	34·3 995	35·3 995	36·3 994
25	27 995	28 995	28·9 995	29·9 995	30·9 995	31·9 994	32·9 994	33·9 994	34·9 994	35·9 994

Temperature. C.	41c	42c	43c	44c	45c	46c	47c	48c	49c	50c
Deg. 10	43 1003	44 1004	45 1004	46 1004	46·9 1004	47·9 1004	48·9 1004	49·9 1004	50·9 1004	51·8 1004
11	42·6 1003	43·6 1003	44·6 1003	45·6 1003	46·6 1003	47·6 1003	48·6 1003	49·5 1003	50·5 1003	51·5 1003
12	42·2 1002	43·2 1002	44·2 1002	45·2 1002	46·2 1002	47·2 1002	48·2 1002	49·2 1002	50·2 1002	51·1 1002
13	41·8 1001	42·8 1001	43·8 1001	44·8 1002	45·8 1002	46·8 1002	47·8 1002	48·8 1002	49·8 1002	50·8 1002
14	41·4 1001	42·4 1001	43·4 1001	44·4 1001	45·4 1001	46·4 1000	47·4 1001	48·4 1001	49·4 1001	50·4 1000
15	41 1000	42 1000	43 1000	44 1000	45 1000	46 1000	47 1000	48 1000	49 1000	50 1000
16	40·6 999	41·6 999	42·6 999	43·6 999	44·6 999	45·6 999	46·6 999	47·6 999	48·6 999	49·6 999

Alcometrical Table of real Strength, by M. Gay Lussac (*continued*).

Temperature. C.	41c	42c	43c	44c	45c	46c	47c	48c	49c	50c
Deg. 17	40·2 999	41·2 999	42·2 999	43·2 998	44·9 998	45·2 998	46·2 998	47·2 998	48·2 998	49·2 998
18	39·8 998	40·8 998	41·8 998	42·8 998	43·8 998	44·9 998	45·9 998	46·9 998	47·9 998	48·9 998
19	39·4 997	40·4 997	41·4 997	42·5 997	43·5 997	44·5 997	45·5 997	46·5 997	47·5 997	48·5 997
20	39 997	40 997	41 997	42·1 997	43·1 996	44·1 996	45·1 996	46·1 996	47·2 996	48·2 996
21	38·6 996	39·6 996	40·6 996	41·7 996	42·7 996	43·7 996	44·8 996	45·8 996	46·8 995	47·8 995
22	38·2 996	39·2 995	40·2 995	41·3 995	42·3 995	43·3 995	44·3 995	45·3 995	46·4 995	47·4 995
23	37·8 995	38·8 995	39·8 995	40·9 994	41·9 994	42·9 994	43·9 994	44·9 994	46 994	47 994
24	37·4 994	38·4 994	39·4 994	40·5 994	41·5 994	42·5 994	43·6 994	44·6 993	45·6 993	46·6 993
25	37 994	38 994	39 993	40·1 993	42·1 993	42·2 993	43·2 993	44·2 993	45·2 993	46·3 993

Temperature. C.	51c	52c	53c	54c	55c	56c	57c	58c	59c	60c
Deg 10	52·8 1004	53·8 1004	54·8 1004	55·8 1004	56·8 1004	57·8 1004	58·8 1004	59·7 1004	60·7 1004	61·7 1004
11	52·5 1003	53·5 1003	54·4 1003	55·4 1003	56·4 1003	57·4 1003	58·4 1003	59·4 1003	60·4 1003	61·4 1003
12	52·1 1002	53·1 1002	54·1 1002	55 1002	56 1002	57 1002	58 1002	59 1002	60 1002	61 1002
13	51.8 1002	52·7 1002	53·7 1002	54·7 1002	55·7 1002	56·7 1002	57·7 1002	58·7 1002	59·7 1002	60·7 1002
14	51·4 1001	52·3 1001	53·3 1001	54·3 1001	55·3 1001	56·3 1001	57·3 1001	58·3 1001	59·3 1001	60·3 1001
15	51 1000	52 1000	53 1000	54 1000	55 1000	56 1000	57 1000	58 1000	59 1000	60 1000
16	50·6 999	51·6 999	52·6 999	53·6 999	54·6 999	55·6 999	56·6 999	57·6 999	58·6 999	59·6 999
17	50·3 998	51·3 998	52·3 998	53·3 998	54·3 998	55·3 998	56·3 998	57·3 998	58·3 998	59·3 998
18	49·9 998	50·9 998	51·9 998	52·9 998	53·9 998	54·9 998	55·9 998	56·9 997	57·9 997	58·9 997
19	49·5 997	50·6 997	51·6 997	52·6 997	53·6 997	54·6 997	55·6 997	56·6 997	57·6 997	58·6 997
20	49·2 996	50·2 996	51·2 996	52·2 996	53·2 996	54·2 996	55·2 996	56·2 996	57·2 996	58·2 996
21	48·8 995	49·8 995	50·8 995	51·8 995	52·9 995	53·9 995	54·9 995	55·9 995	56·9 995	57·9 995
22	48·4 995	49·4 995	50·4 995	51·4 994	52·5 994	53·5 994	54·5 994	55·5 994	56·5 994	57·5 994
23	48 994	49·1 994	50·1 994	51·1 994	52·1 994	53·1 994	54·1 994	55·1 993	56·1 993	57·1 993
24	47·6 993	48·7 993	49·7 993	50·7 993	51·8 993	52·8 993	53·8 993	54·8 993	55·8 993	56·8 992
25	47·3 993	48·3 993	49·3 993	50·3 992	51·4 992	52·4 992	53·4 992	54·4 992	55·5 992	56·5 992

Alcometrical Table of real Strength, by M. Gay Lussac (*continued*).

Temperature. C.	61c	62c	63c	64c	65c	66c	67c	68c	69c	70c
Deg. 10	62·7 / 1004	63·7 / 1004	64·7 / 1004	65·7 / 1004	66·7 / 1004	67·6 / 1004	68·6 / 1004	69·6 / 1004	70·6 / 1004	71·6 / 1004
11	62·4 / 1003	63·4 / 1003	64·4 / 1003	65·4 / 1003	66·4 / 1003	67·3 / 1003	68·3 / 1003	69·3 / 1004	70·3 / 1004	71·3 / 1004
12	62 / 1002	63 / 1002	64 / 1002	65 / 1002	66 / 1002	67 / 1002	68 / 1003	69 / 1003	70 / 1003	71 / 1003
13	61.7 / 1002	62·7 / 1002	63·7 / 1002	64·7 / 1002	65 7 / 1002	66·7 / 1002	67·7 / 1002	68·7 / 1002	69·6 / 1002	70·6 / 1002
14	61·3 / 1001	62·3 / 1001	63·3 / 1001	64·3 / 1001	65·3 / 1001	66·3 / 1001	67·3 / 1001	68·3 / 1001	69·3 / 1001	70·3 / 1001
15	61 / 1000	62 / 1000	63 / 1000	64 / 1000	65 / 1000	66 / 1000	67 / 1000	68 / 1000	69 / 1000	70 / 1000
16	60·6 / 999	61·7 / 999	62·7 / 999	63·7 / 999	64·7 / 999	65·7 / 999	66·7 / 999	67·7 / 999	68·7 / 999	69·7 / 999
17	60·3 / 998	61·3 / 998	62·3 / 998	63·3 / 998	64·3 / 998	65·3 / 998	66·3 / 998	67·3 / 998	68·3 / 998	69·3 / 998
18	59·9 / 997	61 / 997	62 / 997	63 / 997	64 / 997	65 / 997	66 / 997	67 / 997	68 / 997	69 / 997
19	59·6 / 997	60·6 / 997	61·6 / 997	62·7 / 997	63·7 / 997	64·7 / 997	65·7 / 997	66·7 / 997	67·7 / 996	68·7 / 996
20	59·2 / 996	60·3 / 996	61·3 / 996	62·3 / 996	63·3 / 996	64·3 / 996	65·4 / 996	66·4 / 996	67·4 / 996	68·4 / 996
21	58·9 / 995	59·9 / 995	61 / 995	62 / 995	63 / 995	64 / 995	65 / 995	66 / 995	67 / 995	68·1 / 995
22	58·5 / 994	59·5 / 994	60·6 / 994	61·6 / 994	62·7 / 994	63·7 / 994	64·7 / 994	65·7 / 994	66·7 / 994	67·8 / 994
23	58·1 / 993	59·2 / 993	60·2 / 993	61·3 / 993	62·3 / 993	63·3 / 993	64·3 / 993	65·4 / 993	66·4 / 993	67·4 / 993
24	57·8 / 992	58·9 / 992	59·9 / 992	61 / 992	62 / 992	63 / 992	64 / 992	65 / 992	66 / 992	67·1 / 992
25	57·5 / 992	58·5 / 992	·59·5 / 992	60·6 / 991	61·6 / 991	62·6 / 991	63·7 / 991	64·7 / 991	65·7 / 991	66·7 / 991

Temperature. C.	71c	72c	73c	74c	75c	76c	77c	78c	79c	80c
Deg. 10	72·6 / 1004	73·5 / 1004	74·5 / 1005	75·5 / 1005	76·5 / 1005	77·5 / 1005	78·5 / 1005	79·5 / 1005	80·5 / 1005	81·5 / 1005
11	72·3 / 1004	73·2 / 1004	74·2 / 1004	75·2 / 1004	76·2 / 1004	77·2 / 1004	78·2 / 1004	79·2 / 1004	SO·2 / 1004	81·2 / 1004
12	72 / 1003	72·9 / 1003	73·9 / 1003	74·9 / 1003	75·9 / 1003	76·9 / 1003	77·9 / 1003	78·9 / 1003	79·9 / 1003	80·9 / 1003
13	71·6 / 1002	72·6 / 1002	73·6 / 1002	74·6 / 1002	75·6 / 1002	76·6 / 1002	77·6 / 1002	78·6 / 1002	79·6 / 1002	80·6 / 1002
14	71·3 / 1001	72·3 / 1001	73·3 / 1001	74·3 / 1001	75·3 / 1001	76·3 / 1001	77·3 / 1001	78·3 / 1001	79·3 / 1001	80·3 / 1001
15	71 / 1000	72 / 1000	73 / 1000	74 / 1000	75 / 1000	76 / 1000	77 / 1000	78 / 1000	79 / 1000	80 / 1000
16	70·7 / 999	71·7 / 999	72·7 / 999	73·7 / 999	74·7 / 999	75·7 / 999	76·7 / 999	77·7 / 999	78·7 / 999	79·7 / 999
17	70·3 / 998	71·3 / 998	72·3 / 998	73·3 / 998	74·3 / 998	75·4 / 998	76·4 / 998	77·4 / 998	78·4 / 998	79·4 / 998

Alcometrical Table of real Strength, by M. Gay Lussac (*continued*).

Temperature. C.	71c	72c	73c	74c	75c	76c	77c	78c	79c	80c
Deg. 18	·70 997	71 997	72 9.7	73 997	74 997	75·1 997	76·1 997	77·1 997	78·1 997	79·1 997
19	69·7 996	70·7 996	71·7 996	72·7 996	73·7 996	74·7 996	75·8 996	76·8 996	77·8 996	78·8 996
20	69·4 996	70·4 996	71·4 995	72·4 995	73·4 995	74·4 995	75·5 995	76·5 995	77·5 995	78·5 995
21	69·1 995	70·1 995	71·1 995	72·1 991	73·1 991	74·1 991	75·2 994	76·2 994	77·2 994	78·2 994
22	68·8 994	69·8 994	70·8 991	71·8 991	72·8 993	73·8 993	74·8 993	75·9 993	76·9 993	77·9 993
23	68·4 993	69·4 993	70·5 993	71·5 993	72·5 992	73·5 992	74·5 992	75·5 992	76·6 992	77·6 992
24	68·1 992	69·1 992	70·1 992	71·2 992	72·2 992	73·2 992	74·2 992	75·2 991	76·3 991	77·3 991
25	67·8 991	68·8 991	69·8 991	70·8 991	71 8. 991	72·8 991	73·9 991	74·9 991	76 991	77 991

Temperature. C.	81c	82c	83c	84c	85c	86c	87c	88c	89c	90c
Deg. 10	82·4 1005	83·4 1005	84·4 1005	85·4 1005	86·4 1005	87·4 1005	88·3 1005	89·3 1005	90·2 1005	91·2 1005
11	82·2 1004	83·1 1004	84·1 1004	85·1 1004	86·1 1004	87·1 1004	88 1004	89 1004	90 1004	91 1004
12	81·9 1003	82·9 1003	83·9 1003	84·8 1003	85·8 1003	86·8 1003	87·8 1003	88·7 1003	89·7 1003	90·7 1003
13	81.6 1002	82·6 1002	83·6 1002	84·6 1002	85·5 1002	86·5 1002	87·5 1002	88·5 1002	89·5 1002	90·5 1002
14	81·3 1001	82·3 1001	83·3 1001	84·3 1001	85·3 1001	86·3 1001	87·3 1001	88·2 1001	89·2 1001	90·2 1001
15	81 1000	82 1000	83 1000	84 1000	85 1000	86 1000	87 1000	88 1000	89 1000	90 1000
16	80·7 999	81·7 999	82·7 999	83·7 999	84·7 999	85·7 999	86·7 999	87·7 999	88·7 999	89·7 999
17	80·4 998	81·4 998	82·4 998	83·4 998	84·4 998	85·4 998	86·4 998	87·4 998	88·4 998	89·5 998
18	80·1 997	81·1 997	82·1 997	83·1 997	84·1 997	85·2 997	86·2 997	87·2 997	88·2 997	89·2 997
19	79·8 996	80·8 996	81·9 996	82·9 996	83·9 996	84·9 996	85·9 996	86·9 996	87·9 996	88·9 996
20	79·5 995	80·5 995	81·6 995	82·6 995	83·6 995	84·6 995	85·6 995	86·6 995	87·7 995	88·7 995
21	79·2 994	80·2 994	81·3 994	82·3 994	83·3 994	84·3 994	85·3 994	86·4 994	87·4 994	88·4 994
22	78·9 993	79·9 993	81 993	82 993	83 993	84 993	85 993	86·1 993	87·1 993	88·2 993
23	78·6 992	79·6 992	80·7 992	81·7 992	82·7 992	.83·8 992	84·8 992	85·8 992	86·8 992	87·9 992
24	78·3 991	79·3 991	80·4 991	81·4 991	82·4 991	83·5 991	84·5 991	85·5 991	86·5 991	87·6 991
25	78 991	79 991	80·1 990	81·1 990	82·1 990	83·2 990	84·2 990	85·2 990	86·3 990	87·4 990

I consider the preceding table, which I have extracted from the longer tables of M. Gay Lussac, as an important addition to the resources of British dealers and manufacturing chemists. With the aid of his little instrument, which may be got for a trifle from its ingenious maker, M. Collardeau, Rue Faubourg St. Martin, at Paris, or constructed by one of the London hydrometer artists, the per centage of real alcohol, and the real value of any spirituous liquor, may be determined to sufficient nicety for most purposes, in a far easier manner than by any instruments now used in this country. It has been adopted by the Swedish government, with M. Gay Lussac's tables.

M. Gay Lussac's table gives, by inspection, the true bulk of the spirits as corrected for temperature; that is, their volume, if of the normal temperature of 15° Cent. (59° Fahr.) _ Now this is important information; for, if a person buys 1000 gallons of spirits in hot weather, and pays for them exactly according to their strength corrected for temperature, he will not have 1000 gallons when the weather is in its mean state. He may lose, in this way, several gallons without being aware of it from his hydrometer.

Sometimes, after moist autumns, when damaged grain abounds, the alcohol distilled from its fermented wash contains a peculiar volatile body. When we apply our nose to this species of spirits in its hot state, the volatile substance dissolved in it irritates the eyes and nostrils: it has very nearly the same smell as an alcoholic solution of cyanogen, as any chemist may discover by standing near the discharge pipe of the refrigeratory worm of a raw-grain whiskey still. Such spirits intoxicate more strongly than pure spirits of the same strength, and excite, in many persons, even temporary phrensy. It is a volatile fatty matter, of a very fetid odor, when obtained by itself, as I have procured it in cold weather at some of the great distilleries in Scotland. It does not combine with bases. At the end of a few months, it spontaneously decomposes in the spirits, and leaves them in a less nauseous and noxious state. By largely diluting the spirits with water, and distilling at a moderate temperature, the greater part of this oil may be separated. Part of it comes over with the strongest alcohol, and part with the latter runnings, which are called by the distillers strong and weak feints. The intermediate portion is purer spirit. The feints are always more or less opalescent, or become so on dilution with water, and then throw up an oily pellicle upon their surface. The charcoals of light wood, such as pine or willow, well calcined, and infused in sufficient quantity with the spirits prior to rectification, will deprive them of the greater part of that oily contamination. Animal charcoal, well calcined, has also been found useful; but it must be macerated for some time with the empyreumatic spirits, before distillation. Another mode of separating that offensive oil is, to agitate the impure spirits with a quantity of a fat oil, such as olive oil, or oil of almonds, to decant off the oil, and re-distil the spirits with a little water.

Some foreign chemists direct empyreumatic or rank spirits to be rectified with the addition of chloride of lime. I have tried this method in every way, and on a considerable scale, but never found the spirits to be improved by it. They were rather deteriorated. See *Brandy, Distillation, Fermentation, Gin, Rum, Whiskey.*

Anhydrous or absolute alcohol, when swallowed, acts as a mortal poison, not only by its peculiar stimulus on the nervous system, but by its abstracting the aqueous particles from the soft tissue of the stomach, with which it comes in contact, so as to destroy its organization. Alcohol of 0·812 consists, by experiments, of 3 atoms of carbon, 6 of hydrogen, and 2 of oxygen; absolute alcohol consists, probably, of 2 of carbon, 3 of hydrogen, and 1 of oxygen.

ALE. The fermented infusion of pale malted barley, usually combined with infusion of hops. See BEER.

ALEMBIC, a STILL; which see.

ALEMBROTH, salt of. The salt of wisdom, of the alchemists; a compound of bichloride of mercury and sal ammoniac, from which the old white precipitate of mercury is made.

ALGAROTH, powder of. A compound of oxyde and chloride of antimony, being a precipitate obtained by pouring water into the acidulous chloride of that metal.

ALIZARINE. See MADDER.

ALKALI. A class of chemical bodies, distinguished chiefly by their solubility in water, and their power of neutralizing acids, so as to form saline compounds. The alkalis of manufacturing importance are, ammonia, potash, soda, and quinia. These alkalis change the purple color of red cabbage and radishes to a green, the reddened tincture of litmus to a purple, and the color of turmeric and many other yellow dyes to a brown. Even when combined with carbonic acid, the first three alkalis exercise this dicoloring power, which the alkaline earths, lime, and barytes, do not. The same three alkalis have an acrid, and somewhat urinous taste; the first two are energetic solvents of animal matter; and the three combine with oils, so as to form soaps. They unite with water in every proportion, and also with alcohol; and the first three combine with water after being carbonated.

ALKALIMETER. An instrument for measuring the alkaline force or purity of any of the alkalis of commerce. It is founded on the principle, that the quantity of real alkali present in any sample, is proportional to the quantity of acid which a given weight of it can neutralize. See the individual alkalis, POTASH and SODA.

ALKANA, is the name of the root and leaves of *Lawsania inermis*, which have been long employed in the East, to dye the nails, teeth, hair, garments, &c. The leaves, ground and mixed with a little limewater, serve for dyeing the tails of horses in Persia and Turkey.

ALKANET, the root of. (*Anchusa tinctoria.*) A species of bugloss, cultivated chiefly in the neighborhood of Montpellier. It affords a fine red color to alcohol and oils; but a dirty red to water. Its principal use is for coloring ointments, cheeses, and *pommades*. The spirituous tincture gives to white marble a beautiful deep stain.

ALLIGATION. An arithmetical formula, useful, on many occasions, for ascertaining the proportion of constituents in a mixture, when they have undergone no change of volume by chemical action. When alcoholic liquors are mixed with water, there is a condensation of bulk, which renders that arithmetical rule inapplicable. The same thing holds, in some measure, in the union of metals by fusion. See ALLOY.

ALLOY. (*Alliage*, Fr.; *Legirung*, Germ.) This term formerly signified a compound of gold and silver, with some metal of inferior value, but it now means any compound of any two or more metals whatever. Thus, bronze is an alloy of copper and tin; brass, an alloy of copper and zinc; and type metal, an alloy of lead and antimony. All the alloys possess metallic lustre, even when cut or broken to pieces; they are opaque; are excellent conductors of heat and electricity; are frequently susceptible of crystallizing; are more or less ductile, malleable, elastic, and sonorous. An alloy which consists of metals differently fusible is usually malleable in the cold, and brittle when hot, as is exemplified with brass and gong metal.

Many alloys consist of definite or equivalent proportions of the simple component metals, though some alloys seem to form in any proportion, like combinations of salt or sugar with water. It is probable that peculiar properties belong to the equivalent or atomic ratio, as is exemplified in the superior quality of brass made in that proportion.

One metal does not alloy indifferently with every other metal, but it is governed in this respect by peculiar affinities; thus, silver will hardly unite with iron, but it combines readily with gold, copper, and lead. In comparing the alloys with their constituent metals, the following differences may be noted; in general, the ductility of the alloy is less than that of the separate metals, and sometimes in a very remarkable degree; on the contrary, the alloy is usually harder than the mean hardness of its constituents. The mercurial alloys or amalgams are, perhaps, exceptions to this rule.

The specific gravity is rarely the mean between that of each of its constituents, but is sometimes greater and sometimes less, indicating, in the former case, an approximation, and in the latter, a recedure, of the particles from each other in the act of their union. The following tables of binary alloys exhibit this circumstance in experimental detail:—

Alloys having a density greater than the mean of their constituents.	Alloys having a density less than the mean of their constituents.
Gold and zinc	Gold and silver
Gold and tin	Gold and iron
Gold and bismuth	Gold and lead
Gold and antimony	Gold and copper
Gold and cobalt	Gold and iridium
Silver and zinc	Gold and nickel
Silver and lead	Silver and copper
Silver and tin	Silver and lead
Silver and bismuth	Iron and bismuth
Silver and antimony	Iron and antimony
Copper and zinc	Iron and lead
Copper and tin	Tin and lead
Copper and palladium	Tin and palladium
Copper and bismuth	Tin and antimony
Lead and antimony	Nickel and arsenic
Platinum and molybdinum	Zinc and antimony.
Palladium and bismuth.	

It would be hardly possible to infer the melting point of an alloy from that of each of its constituent metals; but, in general, the fusibility is increased by mutual affinity in their state of combination. Of this, a remarkable instance is afforded in the fusible metal consisting of 8 parts of bismuth, 5 of lead, and 3 of tin, which melts at the

heat of boiling water, or 212° Fahr., though the melting point deduced from the mean of its components should be 514°. This alloy may be rendered still more fusible by adding a very little mercury to it, when it forms an excellent material for certain anatomical injections, and for filling the hollows of carious teeth. Nor do the colors of alloys depend, in any considerable degree, upon those of the separate metals; thus, the color of copper, instead of being rendered paler by a large addition of zinc, is thereby converted into the rich-looking pinchbeck metal.

By means of alloys, we multiply, as it were, the numbers of useful metals, and sometimes give usefulness to such as are separately of little value. Since these compounds can be formed only by fusion, and since many metals are apt to oxydize readily at their melting temperature, proper precautions must be taken in making alloys to prevent this occurrence, which is incompatible with their formation. Thus, in combining tin and lead, rosin or grease is usually put on the surface of the melting metals, the carbon produced by the decomposition of which protects them, in most cases, sufficiently from oxydizement. When we wish to combine tin with iron, as in the tinning of cast-iron tea kettles, we rub sal ammoniac upon the surfaces of the hot metals in contact with each other, and thus exclude the atmospheric oxygen by means of its fumes. When there is a notable difference in the specific gravities of the metals which we wish to combine, we often find great difficulties in obtaining homogeneous alloys; for each metal may tend to assume the level due to its density, as is remarkably exemplified in alloys of gold and silver made without adequate stirring of the melting metals. If the mass be large, and slow of cooling, after it is cast in an upright cylindrical form, the metals sometimes separate, to a certain degree, in the order of their densities. Thus, in casting large bells and cannons with copper alloys, the bottom of the casting is apt to contain too much copper and the top too much tin, unless very dexterous manipulation in mixing the fused materials have been employed immediately before the instant of pouring out the melted mass. When such inequalities are observed, the objects are broken and re-melted, after which they form a much more homogeneous alloy. This artifice of a double melting is often had recourse to, and especially in casting the alloys for the specula of telescopes.

When we wish to alloy three or more metals, we often experience difficulties, either because one of the metals is more oxydable, or denser, or more fusible, than the others, or because there is no direct affinity between two of the metals. In the latter predicament, we shall succeed better by combining the three metals, first in pairs, for example, and then melting the two pairs together. Thus, it is difficult to unite iron with bronze directly; but if, instead of iron, we use tin plate, we shall immediately succeed, and the bronze, in this manner, acquires valuable qualities from the iron. Thus, also, to render brass better adapted for certain purposes, a small quantity of lead ought to be added to it, but this cannot be done directly with advantage: it is better to melt the lead first along with the zinc, and then to add this alloy to the melting copper, or the copper to that alloy, and fuse them together.

We have said that the difference of fusibility was often an obstacle to metallic combination, but this circumstance may also be turned to advantage in decomposing certain alloys by the process called *eliquation*. By this means silver may be separated from copper, if a considerable quantity of lead be first alloyed with the said copper; this alloy is next exposed to a heat just sufficient to melt the lead, which then sweats out, so to speak, from the pores of the copper, and carries along with it the greater part of the silver, for which it has a strong affinity. The lead and the silver are afterwards separated from each other, in virtue of their very different oxydability, by the action of heat and air.

One of the alloys most useful to the arts is brass; it is more ductile and less easily oxydized than even its copper constituent, notwithstanding the opposite nature of the zinc. This alloy may exist in many different proportions, under which it has different names, as tombac, similor, pinchbeck, &c. Copper and tin form, also, a compound of remarkable utility, known under the names of hard brass, for the bushes, steps, and bearings of the axles, arbors, and spindles in machinery; and of bronze, bell-metal, &c. Gold and silver, in their pure state, are too soft and flexible to form either vessels or coins of sufficient strength and durability; but when alloyed with a little copper, they acquire the requisite hardness and stiffness for these and other purposes.

When we have occasion to unite several pieces of the same or of different metals, we employ the process called *soldering*, which consists in fixing together the surfaces by means of an interposed alloy, which must be necessarily more fusible than the metal or metals to be joined. That alloy must also consist of metals which possess a strong affinity for the substances to be soldered together. Hence each metal would seem to require a particular kind of solder, which is, to a certain extent, true. Thus, the solder for gold trinkets and plate is an alloy of gold and silver, or gold and copper; that of silver trinkets, is an alloy of silver and copper; that of copper is either fine tin, for pieces that must not be exposed to the fire, or a brassy alloy called hard solder, of which

the zinc forms a considerable proportion. The solder of lead and tinplate is an alloy of lead and tin, and that of tin is the same alloy with a little bismuth. Tinning, gilding, and silvering may also be reckoned a species of alloys, since the tin, gold, and silver are superficially united in these cases to other metals.

Metallic alloys possess usually more tenacity than could be inferred from their constituents; thus, an alloy of twelve parts of lead with one of zinc has a tenacity double that of zinc. Metallic alloys are much more easily oxydized than the separate metals, a phenomenon which may be ascribed to the increase of affinity for oxygen which results from the tendency of the one of the oxydes to combine with the other. An alloy of tin and lead heated to redness takes fire, and continues to burn for some time like a piece of bad turf.

Every alloy is, in reference to the arts and manufactures, a new metal, on account of its chemical and physical properties. A vast field here remains to be explored. Not above sixty alloys have been studied by the chemists out of many hundred which may be made; and of these very few have yet been practically employed. Very slight modifications often constitute very valuable improvements upon metallic bodies. Thus, the brass most esteemed by turners at the lathe contains from two to three per cent. of lead; but such brass does not work well under the hammer; and, reciprocally, the brass which is best under the hammer is too tough for turning.

That metallic alloys tend to be formed in definite proportions of their constituents is clear from the circumstance that the native gold of the auriferous sands is an alloy with silver, in the ratios of 1 atom of silver united to 4, 5, 6, 12 atoms of gold, but never with a fractional part of an atom. Also, in making an amalgam of 1 part of silver with 12 or 15 of mercury, and afterwards squeezing the mixture through chamois leather, the amalgam separates into 2 parts: one, containing a small proportion of silver and much mercury, passes through the skin; and the other, formed of 1 of silver and 8 of mercury, is a compound in definite proportions, which crystallizes readily, and remains in the knot of the bag. An analogous separation takes place in the tinning of mirrors; for on loading them with the weights, a liquid amalgam of tin is squeezed out, while another amalgam remains in a solid form composed of tin and mercury in uniform atomic proportions. But, as alloys are generally soluble, so to speak, in each other, this definiteness of combination is masked and disappears in most cases.

M. Chaudet has made some experiments on the means of detecting the metals of alloys by the cupelling furnace, and they promise useful applications. The testing depends upon the appearances exhibited by the metals and their alloys when heated on a cupel. Pure tin, when heated this way, fuses, becomes of a grayish black color, fumes a little, exhibits incandescent points on its surface, and leaves an oxyde, which, when withdrawn from the fire, is at first lemon-yellow, but when cold, white. Antimony melts, preserves its brilliancy, fumes, and leaves the vessel colored lemon-yellow when hot, but colorless when cold, except a few spots of a rose tint. Zinc burns brilliantly, forming a cone of oxyde; and the oxyde, much increased in volume, is, when hot, greenish, but when cold, perfectly white. Bismuth fumes, becomes covered with a coat of melted oxyde, part of which sublimes, and the rest enters the pores of the cupel; when cold, the cupel is of a fine yellow color, with spots of a greenish hue. Lead resembles bismuth very much; the cold cupel is of a lemon-yellow color. Copper melts, and becomes covered with a coat of black oxyde; sometimes spots of a rose tint remain on the cupel.

Alloys.— Tin 75, antimony 25, melt, become covered with a coat of black oxyde, have very few incandescent points; when cold, the oxyde is nearly black, in consequence of the action of the antimony: a $\frac{1}{400}$ part of antimony may be ascertained in this way in the alloy. An alloy of antimony, containing tin, leaves oxyde of tin in the cupel: a $\frac{1}{100}$ part of tin may be detected in this way. An alloy of tin and zinc gives an oxyde which, while hot, is of a green tint, and resembles philosophic wool in appearance. An alloy containing 99 tin, 1 zinc, did not present the incandescent points of pure tin, and gave an oxyde of greenish tint when cold. Tin 95, bismuth 5 parts, gave an oxyde of a gray color. Tin and lead give an oxyde of a rusty brown color. An alloy of lead and tin, containing only 1 per cent. of the latter metal, when heated, does not expose a clean surface, like lead, but is covered at times with oxyde of tin. Tin 75, and copper 25, did not melt, gave a black oxyde: if the heat be much elevated, the under part of the oxyde is white, and is oxyde of tin; the upper is black, and comes from the copper. The cupel becomes of a rose color. If the tin be impure from iron, the oxyde produced by it is marked with spots of a rust color.

The degree of affinity between metals may be in some measure estimated by the greater or less facility with which, when of different degrees of fusibility or volatility, they unite, or with which they can, after union, be separated by heat. The greater or less tendency to separate into differently proportioned alloys, by long-continued fusion, may also give some information upon the subject. Mr. Hatchett remarked, in his

elaborate researches on metallic alloys, that gold made standard with the usual precautions, by silver, copper, lead, antimony, &c., and then cast, after long fusion, into vertical bars, was by no means a uniform compound; but that the top of the bar, corresponding to the metal at the bottom of the crucible, contained the larger proportion of gold. Hence, for a more thorough combination, two red-hot crucibles should be employed, and the liquefied metals should be alternately poured from the one into the other. To prevent unnecessary oxydizement from the air, the crucibles should contain, besides the metal, a mixture of common salt and pounded charcoal. The metallic alloy should also be occasionally stirred up with a rod of pottery ware.

The most direct evidence of a chemical change having been effected in alloys is, when the compound melts at a lower temperature than the mean of its ingredients. Iron, which is nearly infusible, acquires almost the fusibility of gold when alloyed with this precious metal. The analogy is here strong with the increase of solubility which salts acquire by mixture, as is exemplified in the difficulty of crystallizing residuums of saline solutions, or mother waters, as they are called.

In common cases the specific gravity affords a good criterion whereby to judge of the proportion of two metals in an alloy. But a very fallacious rule has been given in some respectable works for computing the specific gravity that should result from the alloying of given quantities of two metals of known densities, supposing no chemical condensation or expansion of volume to take place. Thus, it has been taught, that if gold and copper be united in equal weights, the computed specific gravity is merely the arithmetical mean between the numbers denoting the two specific gravities. Whereas the specific gravity of any alloy must be computed by dividing the sum of the two weights by the sum of the two volumes, compared, for convenience sake, to water reckoned unity. Or, in another form, the rule may be stated thus :—Multiply the sum of the weights into the products of the two specific-gravity numbers for a numerator ; and multiply each specific gravity-number into the weight of the other body, and add the two products together for a denominator. The quotient obtained by dividing the said numerator by the denominator, is the truly computed mean specific gravity of the alloy. On comparing with that density, the density found by experiment, we shall see whether expansion or condensation of volume has attended the metallic combination. Gold having a specific gravity of 19·36, and copper of 8·87, when they are alloyed in equal weights, give,

by the fallacious rule of the arithmetical mean of the densities $\dfrac{19·36 + 8·87}{2} = 14·11$;

whereas the rightly computed mean density is only 12·16. It is evident that, on comparing the first result with experiment, we should be led to infer that there had been a prodigious condensation of volume, though expansion has actually taken place. Let W, w be the two weights ; P, p the two specific gravities, then M, the mean specific gravity, is given by the formula—

$$M = \frac{(W + w)\, Pp}{Pw + pW} \;::\; 2 \,\triangle = -\frac{(P-p)^2}{P + p} \cdot = \text{twice}$$

the error of the arithmetical mean ; which is therefore always in excess.

ALMOND. (*Amande*, Fr.; *Mandel*, Germ.) There are two kinds of almond which do not differ in chemical composition, only that the bitter, by some mysterious re-action of its constituents, generates in the act of distillation a quantity of a volatile oil, which contains hydrocyanic acid. Vogel obtained from bitter almonds 8·5 per cent. of husks. After pounding the kernels, and heating them to coagulate the albumen, he procured, by expression, 28 parts of an unctuous oil, which did not contain the 'smallest particle of hydrocyanic acid. The whole of the oil could not be extracted in this way. The expressed mass, treated with boiling water, afforded sugar and gum, and, in consequence of the heat, some of that acid. The sugar constitutes 6·5 per cent. and the gum 3. The vegetable albumen extracted, by means of caustic potash, amounted to 30 parts : the vegetable fibre to only 5. The poisonous aromatic oil, according to Robiquet and Boutron-Charlard, does not exist ready-formed in the bitter almond, but seems to be produced under the influence of ebullition with water. These chemists have shown that bitter almonds deprived of their unctuous oil by the press, when treated first by alcohol, and then by water, afford to neither of these liquids any volatile oil. But alcohol dissolves out a peculiar white crystalline body, without smell, of a sweetish taste at first, and afterwards bitter, to which they gave the name of *amygdaline*. This substance does not seem convertible into volatile oil.

Sweet almonds, by the analysis of Boullay, consist of 54 parts of the bland almond oil, 6 of uncrystallizable sugar, 3 of gum, 24 of vegetable albumen, 24 of woody fibre, 5 of ·husks, 3·5 of water, 0·5 of acetic acid, including loss. We thus see that sweet almonds contain nearly twice as much oil as bitter almonds do.

ALMOND OIL. A bland fixed oil, obtained usually from bitter almonds by the action of a hydraulic press, either in the cold, or aided by hot iron plates. See OIL.

ALOE. A series of trials has been made within a few years at Paris to ascertain the comparative strength of cables made of hemp and of the aloe from Algiers; and they are said to have all turned to the advantage of the aloe. Of cables of equal size, that made of aloe raised a weight of 2,000 kilogrammes (2 tons nearly); that made of hemp, a weight of only 400 kilogrammes. At the exposition of objects of national industry, two years ago, in Brussels, I saw aloe cordage placarded, as being far preferable to hempen. See Rope.

ALUDEL. A pear-shaped vessel open at either end, of which a series are joined for distilling mercury in Spain. See Mercury.

ALUM. (Alun, Fr.; Alaun, Germ.) A saline body, consisting of the earth of clay, called alumina by the chemists, combined with sulphuric acid and potash, or sulphuric acid and ammonia, into a triple compound. It occurs in the crystallized form of octahedrons, has an acerb subacid taste, and reddens the blue color of litmus or red cabbage.

Alum works existed many centuries ago at Roccha, formerly called Edessa, in Syria, whence the ancient name of Roch alum given to this salt. It was afterwards made at Foja Nova, near Smyrna, and in the neighborhood of Constantinople. The Genoese, and other trading people of Italy, imported alum from these places into western Europe, for the use of the dyers of red cloth. About the middle of the fifteenth century, alum began to be manufactured at La Tolfa, Viterbo, and Volaterra, in Italy; after which time the importation of oriental alum was prohibited by the pope, as detrimental to the interests of his dominions. The manufacture of this salt was extended to Germany at the beginning of the sixteenth century, and to England at a somewhat later period, by Sir Thomas Chaloner, in the reign of Elizabeth. In its pure state, it does not seem to have been known to the ancients; for Pliny, in speaking of something like plumose alum, says, that it struck a black color with pomegranate juice, which shows that the green vitriol was not separated from it. The stypteria of Dioscorides, and the alumen of Pliny, comprehended, apparently, a variety of saline substances, of which sulphate of iron, as well as alumina, was probably a constituent part. Pliny, indeed, says, that a substance called in Greek Ὑγρα, or watery, probably from its very soluble nature, which was milk-white, was used for dyeing wool of bright colors. This may have been the mountain butter of the German mineralogists, which is a native sulphate of alumina, of a soft texture, waxy lustre, and unctuous to the touch.

The only alum manufactories now worked in Great Britain, are those of Whitby, in England, and of Hurlett and Campsie, near Glasgow, in Scotland; and these derive the acid and earthy constituents of the salt from a mineral called alum slate. This mineral has a blueish or greenish-black color, emits sulphurous fumes when heated, and acquires thereby an aluminous taste. The alum manufactured in Great Britain contains potash as its alkaline constituent; that made in France contains, commonly, ammonia, either alone, or with variable quantities of potash. Alum may in general be examined by water of ammonia, which separates from its watery solutions its earthy basis, in the form of a light flocculent precipitate. If the solution be dilute, this precipitate will float long as an opalescent cloud.

If we dissolve alum in 20 parts of water, and drop this solution slowly into water or caustic ammonia till this be nearly, but not entirely, saturated, a bulky white precipitate will fall down, which, when properly washed with water, is pure aluminous earth or clay, and dried forms 10·82 per cent. of the weight of the alum. If this earth, while still moist, be dissolved in dilute sulphuric acid, it will constitute, when as neutral as possible, the sulphate of alumina, which requires only two parts of cold water for its solution. If we now decompose this solution, by pouring into it water of ammonia, there appears an insoluble white powder, which is subsulphate of alumina, or basic alum; and contains three times as much earth as exists in the neutral sulphate. If, however, we pour into the solution of the neutral sulphate of alumina a solution of sulphate of potash, a white powder will fall if the solutions be concentrated, which is true alum; but if the solutions be dilute, by evaporating their mixture, and cooling it, crystals of alum will be obtained.

When newly precipitated alumina is boiled in a solution of alum, a portion of the earth enters into combination with the salt, constituting an insoluble compound, which falls in the form of a white powder. The same combination takes place, if we decompose a boiling hot solution of alum with a solution of potash, till the mixture appears nearly neutral by litmus paper. This insoluble or basic alum exists native in the alum-stone of Tolfa, near Civita Vecchia, and it consists in 100 parts of 19·72 parts of sulphate of potash, 61·99 basic sulphate of alumina, and 18·29 water. When this mineral is treated with a due quantity of sulphuric acid, it dissolves, and is converted into the crystallizable alum of commerce.

These experimental facts develop the principles of the manufacture of alum, which is prosecuted under various modifications, for its important uses in the arts. Alum seldom occurs ready-formed in nature; occasionally, as an efflorescence on stones, and in

certain mineral waters in the East Indies. The alum of European commerce is fabricated artificially, either from the alum schists or stones, or from clay. The mode of manufacture differs according to the nature of these earthy compounds Some of them, such as the alum-stone, contain all the elements of the salt, but mixed with other matters from which it must be freed. The schists contain only the elements of two of the constituents, namely, clay and sulphur, which are convertible into sulphate of alumina, and this may be then made into alum by adding the alkaline ingredient. To this class belong the alum slates, and other analogous schists, containing brown coal.

1. *Manufacture of Alum from the Alum Stone.*—The alum-stone is a rare mineral, being found in moderate quantity at Tolfa, and in larger in Hungary, at Bereghszasz, and Muszag, where it forms entire beds in a hard substance, partly characterized by numerous cavities, containing drusy crystallizations of alum-stone or basic alum. The larger lumps contain more or fewer flints disseminated through them, and are, according to their quality, either picked out to make alum, or are thrown away. The sorted pieces are roasted or calcined, by which operation apparently the hydrate of alumina, associated with the sulphate of alumina, loses its water, and, as burnt clay, loses its affinity for alum. It becomes, therefore, free; and during the subsequent exposure to the weather the stone gets disintegrated, and the alum becomes soluble in water.

The calcination is performed in common lime-kilns in the ordinary way. In the regulation of the fire it is requisite, here, as with gypsum, to prevent any fusion or running together of the stones, or even any disengagement of sulphuric or sulphurous acids, which would cause a corresponding defalcation in the product of alum. For this reason the contact of the ignited stones with carbonaceous matter ought to be avoided.

The calcined alum-stones, piled in heaps from 2 to 3 feet high, are to be exposed to the weather, and meanwhile they must be continually kept moist by sprinkling them with water. As the water combines with the alum the stones crumble down, and fall, eventually, into a pasty mass, which must be lixiviated with warm water, and allowed to settle in a large cistern. The clear supernatant liquor, being drawn off, must be evaporated, and then crystallized. A second crystallization finishes the process, and furnishes a marketable alum. Thus the Roman alum is made, which is covered with a fine red film of peroxyde of iron.

2. *Alum Manufacture from Alum Schist.*—The greater portion of the alum found in British commerce is made from alum-slate and analogous minerals. This slate contains more or less iron pyrites, mixed with coaly or bituminous matter, which is occasionally so abundant as to render them somewhat combustible. In the strata of brown coal and bituminous wood, where the upper layers lie immediately under clay beds, they consist of the coaly substance rendered impure with clay and pyrites. This triple mixture constitutes the essence of all good alum schists, and it operates spontaneously towards the production of sulphate of alumina. The coal serves to make the texture open, and to allow the air and moisture to penetrate freely, and to change the sulphur and iron present into acid and oxyde. When these schists are exposed to a high temperature in contact with air, the pyrites loses one half of its sulphur, in the form of sublimed sulphur or sulphurous acid, and becomes a black sulphuret of iron, which speedily attracts oxygen, and changes to sulphate of iron, or green vitriol. The brown coal schists contain, commonly, some green vitriol crystals, spontaneously formed in them. The sulphate of iron transfers its acid to the clay, progressively, as the iron, by the action of the air with a little elevation of temperature, becomes peroxydized; whereby sulphate of alumina is produced. A portion of the green vitriol remains, however, undecomposed, and so much the more as there may happen to be less of other salifiable bases present in the clay slate. Should a little magnesia or lime be present, the vitriol gets more completely decomposed, and a portion of Epsom salt and gypsum is produced.

The manufacture of alum from alum schists may be distributed under the six following heads :—1. The preparation of the alum slate. 2. The lixiviation of the slate. 3. The evaporation of the lixivium. 4. The addition of the saline ingredients, or the precipitation of the alum. 5. The washing of the aluminous salts; and, 6. The crystallization.

1. *Preparation of the Alum Slate.*—Some alum slates are of such a nature that, being piled in heaps in the open air, and moistened from time to time, they get spontaneously hot, and by degrees fall into a pulverulent mass, ready to be lixiviated. The greater part, however, require the process of ustulation, from which they derive many advantages. The cohesion of the dense slates is thereby so much impaired that their decomposition becomes more rapid; the decomposition of the pyrites is quickened by the expulsion of a portion of the sulphur; and the ready-formed green vitriol is partly decomposed by the heat, with a transference of its sulphuric acid to the clay, and the production of sulphate of alumina.

Such alum-slates as contain too little bitumen or coal for the roasting process must be interstratified with layers of small coal or brushwood over an extensive surface. At

Whitby the alum rock, broken into small pieces, is laid upon a horizontal bed of fuel, composed of brushwood; but at Hurlett small coal is chiefly used for the lower bed. When about four feet of the rock is piled on, fire is set to the bottom in various parts; and whenever the mass is fairly kindled, more rock is placed over the top. At Whitby this piling process is continued till the calcining heap is raised to the height of 90 or 100 feet. The horizontal area is also augmented at the same time till it forms a great bed nearly 300 feet square, having therefore about 100,000 yards of solid measurement. The rapidity of the combustion is tempered by plastering up the crevices with small schist moistened. When such an immense mass is inflamed, the heat is sure to rise too high, and an immense waste of sulphur and sulphuric acid must ensue. This evil has been noticed at the Whitby works. At Hurlett the height to which the heap is piled is only a few feet, while the horizontal area is expanded; which is a much more judicious arrangement. At Whitby 130 tons of calcined schist produce on an average 1 ton of alum. In this humid climate it would be advisable to pile up on the top of the horizontal strata of brushwood or coal, and schist, a pyramidal mass of schist, which having its surface plastered smooth, with only a few air-holes, will protect the mass from the rains, and at the same time prevent the combustion from becoming too vehement. Should heavy rains supervene, a gutter must be scooped out round the pile for receiving the aluminous lixivium, and conducting it into the reservoir.

It may be observed, that certain alum schists contain abundance of combustible matter, to keep up a suitable calcining heat after the fire is once kindled; and therefore nothing is needed but the first layer of brushwood, which, in this case, may be laid over the first bed of the bituminous schist.

A continual, but very slow heat, with a smothered fire, is most beneficial for the utulation of alum slate. When the fire is too brisk, the sulphuret of iron may run with the earthy matters into a species of slag, or the sulphur will be dissipated in vapor, by both of which accidents the product of alum will be impaired. Those bituminous alum schists which have been used as fuel under steam boilers have suffered such a violent combustion that their ashes yield almost no alum. Even the best regulated calcining piles are apt to burn too briskly in high winds, and should have their draught-holes carefully stopped under such circumstances. It may be laid down as a general rule, that the slower the combustion the richer the roasted ore will be in sulphate of alumina. When the calcination is complete, the heap diminishes to one half its original bulk; it is covered with a light reddish ash, and is open and porous in the interior, so that the air can circulate freely throughout the mass. To favor this access of air, the masses should not be too lofty; and in dry weather a little water should be occasionally sprinkled on them, which, by dissolving away some of the saline matter, will make the interior more open to the atmosphere.

When the calcined mineral becomes thoroughly cold, we may proceed to the lixiviation. But as, from the first construction of the piles or beds till their complete calcination, many weeks, or even months, may elapse, care ought to be taken to provide a sufficient number or extent of them, so as to have an adequate supply of material for carrying on the lixiviating and crystallizing processes during the course of the year, or at least during the severity of the winter season, when the calcination may be suspended, and the lixiviation becomes unsatisfactory. The beds are known to be sufficiently decomposed by the efflorescence of the salt which appears upon the stones, from the strong aluminous taste of the ashes, and from the appropriate chemical test of lixiviating an aliquot average portion of the mass, and seeing how much alum it will yield to solution of muriate or sulphate of potash.

2. *The Lixiviation.*—The lixiviation is best performed in stone-built cisterns; those of wood, however strong at first, are soon decomposed, and need repairs. They ought to be erected in the neighborhood of the calcining heaps, to save the labor of transport, and so arranged that the solutions from the higher cisterns may spontaneously flow into the lower. In this point of view, a sloping terrace is the best situation for an alum work. In the lowest part of this terrace, and in the neighborhood of the boiling-house, there ought to be two or more large deep tanks, for holding the crude lixivium, and they should be protected from the rain by a proper shed. Upon a somewhat higher level the cisterns of the clear lixivium may be placed. Into the highest range of cisterns the calcined mineral is to be put, taking care to lay the largest lumps at the bottom, and to cover them with lighter ashes. A sufficient quantity of water is now to be run over it, and allowed to rest for some time. The lixivium may then be drawn off, by a stopcock connected with a pipe at the bottom of the cistern, and run into another cistern at a somewhat lower level. Fresh water must now be poured on the partly exhausted schist, and allowed to remain for a sufficient time. This lixivium, being weak, should be run off into a separate tank. In some cases a third addition of fresh water may be requisite, and the weak lixivium which is drawn off may be reserved for a fresh portion of calcined mineral. In order to save evaporation, it is always requisite to strengthen weak

leys by employing them instead of water for fresh portions of calcined schist. Upon the ingenious disposition and form of these lixiviating cisterns much of the economy and success of an alum work depend. The hydrometer should be always used to determine the degree of concentration which the solutions acquire.

The lixiviated stone, being thus exhausted of its soluble ingredients, is to be removed from the cisterns, and piled up in a heap in any convenient place, where it may be left either spontaneously to decompose, or, after drying, may be subjected to another calcination.

The density of the solution may be brought, upon an average, up to the sp. gr. of from 1·09 to 1·15. The latter density may always be obtained by pumping up the weaker solutions upon fresh calcined mine. This strong liquor is then drawn off, when the sulphate of lime, the oxyde of iron, and the earths are deposited. It is of advantage to leave the liquor exposed for some time, whereby the green vitriol may pass into a persulphate of iron with the deposition of some oxyde, while the liberated acid may combine with some of the clay present, so as to increase the quantity of sulphate of alumina. The manufacture of alum is the more imperfect, as the quantity of sulphate of iron left undecomposed is greater, and therefore every expedient ought to be tried to convert the sulphate of iron into sulphate of alumina.

3. *The evaporation of the Schist Lixivium.*—As the aluminous liquors, however well settled at first, are apt, on the great scale, to deposite earthy matters in the course of their concentration by heat, they are best evaporated by a surface fire, such as that employed at Hurlett and Campsie. A water-tight stone cistern must be built, having a layer of well rammed clay behind the flags or tiles which line its bottom and sides. This cistern may be 4 or 6 feet wide, 2 or 3 feet deep, and 30 or 40 feet long, and it is covered in by an arch of stone or brickwork. At one extremity of this tunnel, or covered canal, a fire-grate is set, and at the other a lofty chimney is erected. The cistern being filled to the brim with the alum ley, a strong fire is kindled in the reverberatory grate, and the flame and hot air are forced to sweep along the surface of the liquor, so as to keep it in constant ebullition, and to carry off the aqueous parts in vapor. The soot which is condensed in the process falls to the bottom, and leaves the body of the liquor clear. As the concentration goes on, more of the rough lixivium is run in from the settling cistern, placed on a somewhat higher level, till the whole gets charged with a clear liquor of a specific gravity sufficiently high for transferring into the proper lead boilers.

At Whitby, the lead pans are 10 feet long, 4 feet 9 inches wide, 2 feet 2 inches deep at the one end, and 2 feet 8 inches deep at the other. This increase of depth and corresponding slope facilitates the decantation of the concentrated lixivium by means of a syphon, applied at the lower end. The bottom of the pan is supported by a series of parallel iron bars, placed very near each other. In these lead pans the liquor is concentrated, at a brisk boiling heat, by means of the flame of a flue beneath them. Every morning the pans are emptied into a settling cistern of stone or lead. The specific gravity of the liquor should be about 1·4 or 1·5, being a saturated solution of the saline matters present. The proper degree of density must vary, however, with different kinds of lixivia, and according to the different views of the manufacturer. For a liquor which consists of two parts of sulphate of alumina, and one part of sulphate of iron, a specific gravity of 1·25 may be sufficient; but for a solution which contains two parts of sulphate of iron to one of sulphate of alumina, so that the green vitriol must be withdrawn first of all by crystallization, a specific gravity of 1·4 may be requisite.

The construction of an evaporating furnace well adapted to the concentration of aluminous and other crude lixivia, is described under SODA. The liquor basin may be made of tiles or flags puddled in clay, and secured at the seams with a good *hydraulic* cement. A mortar made of quicklime mixed with the exhausted schist in powder, and iron turnings, is said to answer well for this purpose. Sometimes over the reverberatory furnace a flat pan is laid, instead of the arched top, into which the crude liquor is put for neutralization and partial concentration. In Germany, such a pan is made of copper, because iron would waste too fast, and lead would be apt to melt. From this preparation basin the under evaporating trough is gradually supplied with hot liquor. At one side of this lower trough there is sometimes a door, through which the sediment may be raked out as it accumulates upon the bottom. Such a contrivance is convenient for this mode of evaporation, and it permits, also, any repairs to be readily made; but, indeed, an apparatus of this kind, well mounted at first, will serve for many years.

In the course of the final concentration of the liquors, it is customary to add some of the mother waters of a former process, the quantity of which must be regulated by a proper analysis and knowledge of their contents. If these mother waters contain much free sulphuric acid, from the peroxydation of their sulphate of iron, they may prove useful in dissolving a portion of the alumina of the sediment which is always present in greater or less quantity.

4. *The precipitation of the Alum by adding Alkaline Salts.*—As a general rule, it is most advantageous to separate, first of all, from the concentrated clear liquors, the alum in the state of powder or small crystals, by addition of the proper alkaline matter, and to leave the mingled foreign salts, such as the sulphate of iron or magnesia, in solution, instead of trying to abstract these salts by a previous crystallization. In this way we not only simplify and accelerate the manufacture of alum, and leave the mother waters to be worked up at any convenient season, but we also avoid the risk of withdrawing any of the sulphate of alumina with the sulphate of iron or magnesia. On this account, the concentration of the liquor ought not to be pushed so far as that, when it gets cold, it should throw out crystals, but merely to the verge of this point. This density may be determined by suitable experiments.

The clear liquor should now be run off into the precipitation cistern, and have the proper quantity of sulphate or muriate of potash, or impure sulphate or carbonate of ammonia added to it. The sulphate of potash, which is the best precipitant, forms 18·34 parts out of 100 of crystallized alum; and therefore that quantity of it, or its equivalent in muriate of potash, or other potash or ammoniacal salts, must be introduced into the aluminous liquor. Since sulphate of potash takes 10 parts of cold water to dissolve it, but is much more soluble in boiling water, and since the precipitation of alum is more abundant the more concentrated the mingled solutions are, it would be prudent to add the sulphate solution as hot as may be convenient; but, as muriate of potash is fully three times more soluble in cold water, it is to be preferred as a precipitant, when it can be procured at a cheap rate. It has, also, the advantage of decomposing the sulphate of iron present into a muriate, a salt very difficult of crystallization, and, therefore, less apt to contaminate the crystals of alum. The quantity of alkaline salts requisite to precipitate the alum, in a granular powder, from the lixivium, depends on their richness in potash or ammonia, on the one hand, and on the richness of the liquors in sulphate of alumina on the other; and it must be ascertained, for each large quantity of product, by a preliminary experiment in a precipitation glass. Here, an aliquot measure of the aluminous liquor being taken, the liquid precipitant must be added in successive portions, as long as it causes any cloud, when the quantity added will be indicated by the graduation of the vessel. A very exact approximation is not practicable upon the great scale; but, as the mother waters are afterwards mixed together in one cistern, any excess of the precipitant, at one time, is corrected by excess of aluminous sulphate at another, and the resulting alum meal is collected at the bottom. When the precipitated saline powder is thoroughly settled and cooled, the supernatant mother water must be drawn off by a pump, or rather a syphon or stopcock, into a lower cistern. The more completely this drainage is effected, the more easily and completely will the alum be purified.

This mother liquor has, generally, a specific gravity of 1·4 at a medium temperature of the atmosphere, and consists of a saturated solution of sulphate or muriate of black and red oxyde of iron, with sulphate of magnesia, in certain localities, and muriate of soda, when the soaper's salt has been used as a precipitant, as also a saturated solution of sulphate of alumina. By adding some of it, from time to time, to the fresh lixivia, a portion of that sulphate is converted into alum; but, eventually, the mother water must be evaporated, so as to obtain from it a crop of ferruginous crystals; after which it becomes capable, once more, of giving up its alum to the alkaline precipitants.

When the aluminous lixivia contain a great deal of sulphate of iron, it may be good policy to withdraw a portion of it by crystallization before precipitating the alum. With this view, the liquors must be evaporated to the density of 1·4, and then run off into crystallizing stone cisterns. After the green vitriol has concreted, the liquor should be pumped back into the evaporating pan, and again brought to the density of 1·4. On adding to it, now, the alkaline precipitants, the alum will fall down from this concentrated solution, in a very minute crystalline powder, very easy to wash and purify. But this method requires more vessels and manipulation than the preceding, and should only be had recourse to from necessity; since it compels us to carry on the manufacture of both the valuable alum and the lower priced salts at the same time; moreover, the copperas extracted at first from the schist liquors carries with it, as we have said, a portion of the sulphate of alumina, and acquires thereby a dull aspect; whereas the copperas obtained after the separation of the alum is of a brilliant appearance.

5. *The washing, or edulcoration, of the Alum Powder.*—This crystalline pulverulent matter has a brownish color, from the admixture of the ferruginous liquors; but it may be freed from it by washing with very cold water, which dissolves not more than one sixteenth of its weight of alum. After stirring the powder and the water well together, the former must be allowed to settle, and then the washing must be drawn off. A second washing will render the alum nearly pure. The less water is employed, and the more effectually it is drained off, the more complete is the process. The second water may be used in the first washing of another portion of

alum powder, in the place of pure water. These washings may be added to the schist lixivia.

6. *The crystallization.*—The washed alum is put into a lead pan, with just enough water to dissolve it at a boiling heat; fire is applied, and the solution is promoted by stirring. Whenever it is dissolved in a saturated state, it is run off into the crystallizing vessels, which are called *roching* casks. These casks are about five feet high, three feet wide in the middle, somewhat narrower at the ends; they are made of very strong staves, nicely fitted to each other, and held together by strong iron hoops, which are driven on *pro tempore*, so that they may be easily knocked off again, in order to take the staves asunder. The concentrated solution, during its slow cooling in these close vessels, forms large regular crystals, which hang down from the top, and project from the sides, while a thick layer or cake lines the whole interior of the cask. At the end of eight or ten days more or less, acccording to the weather, the hoops and staves are removed, when a cask' of apparently solid alum is disclosed to view. The workman now pierces this mass with a pickaxe at the side near the bottom, and allows the mother water of the interior to run off on the sloping stone floor into a proper cistern, whence it is taken and added to another quantity of washed powder to be crystallized with it. The alum is next broken into lumps, exposed in a proper place to dry, and is then put into the finished bing for the market. There is sometimes a little insoluble basic alum (subsulphate) left at the bottom of the cask. This being mixed with the former mother liquors, gets sulphuric acid from them ; or, being mixed with a little sulphuric acid, it is equally converted into alum.

When, instead of potash or its salts, the ammoniacal salts are used, or putrid urine, with the aluminous lixivia, ammoniacal alum is produced, which is perfectly similar to the potash alum in its appearance and properties. At a gentle heat both lose their water of crystallization, amounting to 45½ per cent. for the potash alum, and 48 for the ammoniacal. The quantity of acid is the same in both, as, also, very nearly the quantity of alumina, as the following analyses will show :—

Potash alum.					Ammonia alum.				
Sulphate of potash	-	-	18·34		Sulphate of ammonia	-	-	12·88	
Sulphate of alumina	-	-	36·20		Sulphate of alumina	-	-	38·64	
Water	-	-	-	45·46	Water	-	-	-	48·48
			100·00					100·00	

Or otherwise, Potash alum.			Ammonia alum.		
1 atom sulphate of potash	-	1089·07	1 atom sulphate of ammonia	-	716·7
1	alumina	- 2149·80	1	alumina	- 2149·8
24 water	- - -	2669·52	24 water -	- - -	2699·5
		5938·39			5566·0

Or, Potash alum.					Ammonia alum.				
Alumina	-	-	-	10·82	Alumina	-	-	-	11·90
Potash	-	-	-	9·94	Ammonia	-	-	-	3·89
Sulphuric acid	-	-	33·77		Sulphuric acid	-	-	36·10	
Water -	-	-	-	45·47	Water -	-	-	-	48·11
			100·00					100·00	

When heated pretty strongly, the ammoniacal alum loses its sulphuric acid and ammonia, and only the earth remains. This is a very convenient process for procuring pure alumina. Ammoniacal alum is easily distinguished from the other by the smell of ammonia which it exhales when triturated with quicklime. The Roman alum, made from alum-stone, possesses most of the properties of the schist-made alums, but it has a few peculiar characters : it crystallizes always in opaque cubes, whereas the common alum crystallizes in transparent octahedrons. It is probable that Roman alum is a sulphate of alumina and potash, with a slight excess of the earthly ingredient. It is permanent when dissolved in cold water; for after a slow evaporation it is recovered in a cubical form. But when it is dissolved in water heated to 110° Fahr. and upwards, or when its solution is heated above this pitch, subsulphate of alumina falls, and on evaporation octahedral crystals of common alum are obtained. The exact composition of the Roman alum has not been determined, as far as I know. It probably differs from the other also in its water of crystallization. The Roman alum contains, according to MM. Thenard and Roard, only $\frac{1}{2700}$ of sulphate of iron, while the common commercial

alums contain $\frac{1}{1000}$. It may be easily purified by solution, granulation, crystallization, and washing, as has been already explained. .

Alum is made extensively in France from an artificial sulphate of alumina. For this purpose clays are chosen as free as possible from carbonate of lime and oxyde of iron. They are calcined in a reverberatory furnace, in order to expel the water, to peroxydize the iron, and to render the alumina more easily acted on by the acid. The expulsion of the water renders the clay porous and capable of absorbing the sulphuric acid by capillary attraction. The peroxydation of the iron renders it less soluble in the sulphuric acid; and the silica of the clay, by reacting on the alumina, impairs its aggregation, and makes it more readily attracted by the acid. The clay should, therefore, be moderately calcined; but not so as to indurate it like pottery ware, for it would then suffer a species of silicious combination which would make it resist the action of acids. The clay is usually calcined in a reverberatory furnace, the flame of which serves thereafter to heat two evaporating pans and a basin for containing a mixture of the calcined clay and sulphuric acid. As soon as the clay has become friable in the furnace it is taken out, reduced to powder, and passed through a fine sieve. With 100 parts of the pulverized clay, 45 parts of sulphuric acid, of sp. gr. 1·45, are well mixed, in a stone basin, arched over with brickwork. The flame and hot air of a reverberatory furnace are made to play along the mixture, in the same way as described for evaporating the schist liquors. See SODA. The mixture, being stirred from time to time, is, at the end of a few days, to be raked out, and to be set aside in a warm place, for the acid to work on the clay, during six or eight weeks. At the end of this time it must be washed, to extract the sulphate of alumina. With this view, it may be treated like the roasted alum ores above described. If potash alum is to be formed, this sulphate of alumina is evaporated to the specific gravity of 1·38; but if ammonia alum, to the specific gravity of only 1·24; because the sulphate of ammonia, being soluble in twice its weight of water, will cause a precipitation of pulverulent alum from a weaker solution of sulphate of alumina than the less soluble sulphate of potash could do.

The alum stone, from which the Roman alum is made, contains potash. The following analysis of *alunite*, by M. Cordier, places this fact in a clear light :—

Sulphate of potash	-	-	-	-	18·53
Sulphate of alumina	-	-	-	-	38·50
Hydrate of alumina	-	-	-	-	42·97
					100·00

To transform this compound into alum, it is merely necessary to abstract the hydrate of alumina. The ordinary alum stone, however, is rarely so pure as the above analysis would seem to show; for it contains a mixture of other substances; and the above are in different proportions.

Alum is very extensively employed in the arts, most particularly in dyeing, lake making, dressing sheep-skins, pasting paper, in clarifying liquors, &c. Its purity for the dyer may be tested by prussiate of potash, which will give solution of alum a blue tint in a few minutes if it contain even a very minute portion of iron. A bit of nut-gall is also a good test of iron.

AMADOU. The French name of the spongy combustible substance, called in German *zudersehwamm*, prepared from a species of agaric, the *boletus igniarius*, a kind of mushroom, which grows on the trunks of old oaks, ashes, beeches, &c. It must be plucked in the months of August and September. It is prepared by removing the outer bark with a knife, and separating carefully the spongy substance of a yellow brown color, which lies within it, from the ligneous matter below. This substance is cut into thin slices, and beat with a mallet to soften it, till it can be easily pulled asunder between the fingers. In this state the *boletus* is a valuable substance for stopping oozing hemorrhages, and some other surgical purposes. To convert it into tinder it must receive a finishing preparation, which consists in boiling it in a strong solution of nitre; drying it, beating it anew, and putting it a second time into the solution. Sometimes, indeed, to render it very inflammable, it is imbued with gunpowder, whence the distinction of black and brown amadou.

All the puff balls of the lycopodium genus of plants, which have a fleshy or filamentous structure, yield a tinder quite ready for soaking in gunpowder water. The Hindoos employ a leguminous plant, which they call *solu*, for the same purpose. Its thick spongy stem, being reduced to charcoal, takes fire like amadou.

AMALGAM. When mercury is alloyed with any metal, the compound is called an amalgam of that metal ; as, for example, an amalgam of tin, bismuth, &c.

AMALGAMATION. This is a process used extensively in extracting silver and gold from certain of their ores, founded on the property which mercury has to dissolve these

metals as disseminated in the minerals, and thus to separate them from the earthy matters. See MERCURY, METALLURGY, and SILVER.

AMBER. (*Succin*, Fr.; *Bernstein*, Germ.) A mineral solid, of a yellow color, of various shades, which burns quite away with flame, and consists of carbon, hydrogen, and oxygen, in nearly the same proportions, and the same state of combination, as vegetable resin. Its specific gravity varies, by my trials, from 1·080 to 1·085. It becomes negatively and powerfully electrical by friction. When applied to a lighted candle it takes fire, swells considerably, and exhales a white smoke of a pungent odor; but does not run into drops. Copal, which resembles it in several respects, differs in being softer, and in melting into drops at the flame; and mellite, or honey-stone, which is a mineral of a similar color, becomes white when laid on a red-hot coal.

The texture of amber is resino-vitreous, its fracture conchoidal, and lustre glassy. It is perfectly homogeneous; sufficiently hard to scratch gypsum, and to take a fine polish. It is, however, scratched by calcareous spar. When amber is distilled in a retort, crystalline needles of succinic acid sublime into the dome, and oil of amber drops from the beak into the receiver. Fossil resins, such as that of Highgate, found in the London clay formation, do not afford succinic acid by heat: nor does copal. Amber is occasionally found of a whitish and brownish color.

The most interesting fact relative to this vegeto-mineral is its geological position, which is very characteristic and well determined. It is found almost uniformly in separate nodules, disseminated in the sand, clay, or fragments of lignite of the plastic clay, and lignite formation, situated between the *calcaire grossier* (crag limestone) of the tertiary strata above, and the white chalk below. The size of these nodules varies from a nut to a man's head; but this magnitude is very rare in true amber. It does not occur either in continuous beds, like the chalk flints, nor in veins; but it lies at one time in the earthy or friable strata, which accompany or include the lignites; at another, entangled in the lignites themselves; and is associated with the minerals which constitute this formation, principally the pyrites, the most abundant of all. The pieces of amber found in the sands, and other formations evidently alluvial, those met with on the sea-coasts of certain countries, and especially Pomerania, come undoubtedly from the above geological formation; for the organic matters found still adhering to the amber leave no doubt as to its primitive place. Amber does not, therefore, belong to any postdiluvian or modern soil, since its native bed is covered by three or four series of strata, often of considerable thickness, and well characterized; proceeding upwards from the plastic clay which includes the amber: these are, the crag limestone, the bone gypsum, with its marls, the marly limestone, the upper marl sandstone, which covers it, and, lastly, the fresh water or lacustrine formation, often so thick, and composed of calcareous and silicious rocks.

The amber bed is not, however, always covered with all these strata; and it is even rare to see a great mass of one of them above the ground which contains it; because, were it buried under such strata, it would be difficult to meet with such circumstances as would lay it spontaneously open to the day. But by comparing observations made in different places, relatively to the patches of these formations, which cover the amber deposites, we find that no other mineral formations have been ever seen among them except those above detailed, and thus learn that its geological locality is completely determined.

The proper yellow amber, therefore, or the Borussic, from the country where it has been most abundantly found, belongs to the plastic clay formation, intermediate, in England, between the chalk and the London clay. It is sometimes interposed in thin plates between the layers of the lignites, but more towards the bark of the fibrous lignites, which retain the form of the wood, than towards the middle of the trunk of the tree; a position analogous to that of the resinous matters in our existing ligneous vegetables. The fibrous lignites which thus contain amber belong to the dicotyledinous woods. Hence that substance seems to have been formed during the life of the vegetable upon which it is now incrusted. It must be remembered that the grounds containing the amber are often replete with the sulphates of iron, alumina, and lime, or at least with the pyritous elements of these salts. Some specimens of amber have a surface figured with irregular meshes, indicating a sort of shrinkage from consolidation, and consequently a matter that was at one time fluid, viscid, or merely soft. From optical examination, Dr. Brewster has concluded amber to be of vegetable origin.

The different bodies included in the amber, distinguishable from its transparence, demonstrate, indeed, in the most convincing manner, its primitive state of liquidity or softness. These bodies have long exercised the skill of naturalists. They are generally insects, or remains of insects, and sometimes leaves, stalks, or other portions of vegetables. Certain families of insects occur more abundantly than others. Thus the *hymenoptera*, or insects with four naked membranaceous wings, as the bee and wasp, and the *diptera*, or insects with two wings, as gnats, flies, gadflies, &c.; then come the spider tribe;

some *coleoptera* (insects with crustaceous shells or elytra, which shut together, and form a longitudinal suture down the back), or beetles, principally those which live on trees; such as the *elaterides*, or leapers, and the *chrysomelida*. The lepidoptera, or insects with four membranaceous wings, and pterigostea covered with mail-like scales, are very rare in amber. We perceive from this enumeration, which results from the labors of Germar, Schweiger, &c., that the insects enveloped in this resinous matter are in general such as sit on the trunks of trees, or live in the fissures of their bark. Hitherto, it has not been found possible to refer them to any living species; but it has been observed in general that they resemble more the insects of hot climates than those of the temperate zones.

The districts where amber occurs in a condition fit for mining operations are not numerous; but those in which it is met with in small scattered bits are very abundant. Its principal exploitation is in Eastern Prussia, on the coasts of the Baltic Sea, from Memel to Dantzick, particularly in the neighborhood of Konigsberg, along the shore which runs north and south from Grossdirschheim to Pillau, and in several other places near Dantzick.

It is collected upon this coast in several ways; 1. In the beds of small streams which run near the villages, and in rounded fragments without bark, or in the sand-banks of rivers, in pieces thrown back by the sea, and rounded by the waves. 2. If the pieces thrown up by the waters are not numerous, the fishers, clothed in a leather dress, wade into the sea up to the neck, seek to discover the amber by looking along its surface, and seize it with bag nets, hung at the end of very long poles. They conclude that a great deal of amber has been detached from the cliffs by the sea, when many pieces of lignite (wood coal) are seen afloat. This mode of collecting amber is not free from danger, and the fishers, therefore, advance in troops, to lend each other aid in case of accident; but their success, even thus, is most precarious. 3. The third method of searching for amber is a real mining operation: it consists in digging pits upon the borders of the sandy downs, sometimes to a depth of more than 130 feet. 4. The last mode is by exploring the precipitous sea cliffs in boats, and detaching masses of loose soil from them with long poles terminating in iron hooks; a very hazardous employment. They search the cliffs with great care at the level, where the amber nodules commonly lie, and loosen the seams with their hooks; in which business the boats are sometimes broken against the precipices, or sunk by an avalanche of rubbish.

Amber occurs in Sicily, disseminated in beds of clay and marl, which lie below the crag limestone. It is accompanied with bitumen; and, though a scanty deposite, it is mined for sale. The pieces are coated with a kind of whitish bark, present a variety of colors, and include many insects. Amber is found in a great many places in the sandy districts of Poland, at a very great distance from the sea, where it is mixed with cones of the pine. In Saxony it is met with in the neighborhood of Pretsch and Wittemberg, in a bituminous clay mingled with lignite. At the embouchure of the Jenissey, in Siberia, it occurs likewise along with lignite; as also in Greenland.

Fine amber is considerably valued for making ornamental objects, and the coarser kinds for certain uses in chemistry, medicine, and the arts. The oriental nations prize more highly than the people of Europe trinkets made of amber; and hence the chief commerce of the Pomeranian article is with Turkey. The Prussian government is said to draw an annual revenue of 17,000 dollars from amber. A good pieee of a pound weight fetches 50 dollars. A mass weighing 13 pounds was picked up not long since in Prussia, for which 5000 dollars were offered, and which would bring, in the opinion of the Armenian merchants, from 30,000 to 40,000 dollars at Constantinople. At one time it was customary to bake the opaque pieces of amber in sand, at a gentle heat, for several hours, in order to make it transparent, or to digest it in hot rapeseed oil, with the same view; but how far these processes were advantageous does not appear.

When amber is to be worked into trinkets, it is first split on a leaden plate at a lathe (see GEMS, *Cutting of*), and then smoothed into shape on a Swedish whetstone. It is polished on the lathe with chalk and water, or vegetable oil, and finished by friction with flannel. In these processes the amber is apt to become highly electrical, very hot, and even to fly into fragments. Hence, the artists work the pieces time about, so as to keep each of them crool, and feebly excited. The men are often seized with nervous tremors in their wrists and arms from the electricity. Pieces of amber may be neatly joined by smearing their edges with linseed oil, and pressing them strongly together, while they are held over a charcoal fire. Solid specimens of amber, reported to have been altogether fused by a particular application of heat, are now shown in the royal cabinet of Dresden.

A strong and durable *varnish* is made by dissolving amber in drying linseed oil. For this purpose, however, the amber must be previously heated in an iron pot, over a clear red fire, till it soften and be semi-liquefied. The oil, previously heated, is to be now poured in, with much stirring, in the proportion of 10 ounces to the pound of amber;

and after the incorporation is complete, and the liquid somewhat cooled, a pound of oil of turpentine must be added. Some persons prescribe 2 ounces of melted shellac, though by this means they are apt to deepen the color, already rendered too dark by the roasting.

The fine black varnish of the coachmakers is said to be prepared by melting 16 ounces of amber in an iron pot, adding to it half a pint of drying linseed oil, boiling hot, of powdered resin and asphaltum 3 ounces each: when the materials are well united, by stirring over the fire, they are to be removed, and, after cooling for some time, a pint of warm oil of turpentine is to be introduced.

The *oil of amber* enters into the composition of the old perfume called *eau de luce;* and is convertible, by the action of a small quantity of strong nitric acid, into a viscid mass like shoemakers' rosin, which has a strong odor of musk, and, under the name of artificial musk, has been prescribed, in acoholic solution, as a remedy against hooping cough, and other spasmodic diseases.

Acid of amber (*succinic acid*) is a delicate reagent, in chemistry, for .separating red oxyde of iron from compound metallic solutions.

AMBERGRIS. (*Ambregric*, Fr.; *Ambra*, Germ.)—A morbid secretion of the liver of the spermaceti whale (physeter macrocephalus), found usually swimming upon the sea. It occurs upon the coasts of Coromandel, Japan, the Moluccas, and Madagascar, and has sometimes been extracted from the rectum of whales in the South sea fishery. It has a gray-white color, often with a black streak, or is marbled, yellow and black; has a strong but rather agreeable smell, a fatty taste, is lighter than water, melts at 60° C. (140° F.), dissolves readily in absolute alcohol, in ether, and in both fat and volatile oils. It contains 85 of the fragrant substance called *ambreine*. This is extracted from ambergris by digestion with alcohol of 0·827, filtering the solution, and leaving it to spontaneous evaporation. 'It is thus obtained in the form of delicate white tufts: which are convertible into ambreic acid by the action of nitric acid. Ambergris is used in perfumery.

AMIANTHUS. A mineral in silky filaments, called also ASBESTUS.

AMMONIA. A chemical compound, called also *volatile alkali*. This substance, in its purest state, is a highly pungent gas, possessed of all the mechanical properties of the air, but very condensable with water. It consists of 3 volumes of hydrogen and 1 of azote condensed into two volumes; and hence its density is 0·591, atmospheric air being 1·000. By strong compression and refrigeration it may be liquefied into a fluid, whose specific gravity is 0·76 compared to water 1·000.

Ammonia gas is composed by weight of 82·53 azote and 17·47 hydrogen in 100 parts. It is obtained by mixing muriate of ammonia, commonly called sal ammoniac, with quicklime, in a retort or still, applying a moderate heat, and receiving the gas either over mercury for chemical experiments, or in water to make liquid ammonia for the purposes of medicine and the arts. Woulfe's apparatus is commonly employed for this condensation.

Ammonia is generated in a great many operations, and especially in the decomposition of many organic substances, by fire or fermentation. Urine left to itself for a few days is found to contain much carbonate of ammonia, and hence this substance was at one time collected in great quantities for the manufacture of certain salts of ammonia, and is still used for its alkaline properties in making alum, scouring wool, &c. When woollen rags, horns, bones, and other animal substances are decomposed in close vessels by fire, they evolve a large quantity of ammonia, which distils over in the form of a carbonate. The main source of ammonia now in this country, for commercial purposes, is the coal gas works. A large quantity of watery fluid is condensed in their tar pits, which contains, chiefly, ammonia combined with sulphureted hydrogen and carbonic acid. When this water is saturated with muriatic acid and evaporated it yields muriate of ammonia, or sal ammoniac, somewhat impure. which is afterwards purified by sublimation. See CARBONATE OF AMMONIA and SAL AMMONIAC.

The soot of chimneys where coal is burned contains both sulphate and carbonate of ammonia, and was extensively employed, at one time, to manufacture these salts.

In making water of ammonia on the great scale, a cast iron still should be preferred, and equal weights of quicklime and sal ammoniac should be brought to the consistence of a pap, with water, before the heat is applied. In this case a refrigeratory worm or globe should be interposed between the adopter tube of the capital of the still and the bottles of Woulfe's apparatus. The muriate of lime, or chloride of calcium, which is left in the still when the whole ammonia is expelled, is of no value. Water is capable of condensing easily about one third of its weight of ammonia gas, or 460 times its bulk. The following table of the quantity of ammonia in 100 parts by weight of its aqueous combinations, at successive densities, is the result of very careful experiments made by me, and recorded in the Philosophical Magazine for March, 1821.

*Table of Water of Ammonia or Volatile Alkali, by Dr. Ure.*

Water of 0·900	Ammonia in 100	Water in 100	Specific gravity by experiment.	Mean specific gravity.	Equivalent primes.	
100	26·500	73·500	0·9000			Wat. Am.
95	25·175	74·825	0·9045	0·90452		
90	23·850	76·150	0·9090	0·90909	24 + 76	6 to 1
85	22·525	77·475	0·9133	0·91370		
80	21·200	78·800	0·9177	0·91838	21·25 + 78·75,	7 to 1
75	19·875	80·125	0·9227	0·92308		
70	18·550	81·450	0·9275	0·92780	19·1 + 80·9,	8 to 1
65	17·225	82·775	0·9320	0·93264	17·35 + 82·65,	9 to 1
60	15·900	84·100	0·9363	0·93750	15·9 + 84·1,	10 to 1
55	14·575	85·425	0·9410	0·94241	14·66 + 85·34,	11 to 1
50	13·250	86·750	0·9455	0·94737	13·60 + 86·40,	12 to 1
45	11·925	88·075	0·9510	0·95238	11·9 + 88·1,	14 to 1
40	10·600	89·400	0·9564	0·95744	11·2 + 88·8,	15 to 1
35	9·275	90·723	0·9614	0·96256		
30	7·950	92·050	0·9662	0·96774	8·63 + 91·37,	20 to 1
25	6·625	93·375	0·9716	0·97297	7 + 93,	25 to 1
20	5·300	94·700	0·9768	0·97826	6 + 94,	30 to 1
15	3·975	96·025	0·9828	0·98360	4·5 + 95·5,	40 to 1
10	2·650	97·350	0·9887	0·98900	3 + 97,	60 to 1
5	1·325	98·675	0·9945	0·99447		

AMMONIAC, gum-resin. This is the inspissated juice of an umbelliferous plant (the *dorema armeniacum*) which grows in Persia. It comes to us either in small white tears clustered together, or in brownish lumps, containing many impurities. It possesses a peculiar smell, somewhat like that of asafœtida, and a bitterish taste. It is employed in medicine. Its only use in the arts is for forming a cement to join broken pieces of china and glass, which may be prepared as follows: Take isinglass 1 ounce, distilled water 6 ounces, boil together down to 3 ounces, and add 1½ ounce of strong spirit of wine; boil this mixture for a minute or two; strain it; add, while hot, first, half an ounce of a milky emulsion of gum ammoniac, and then five drams of an alcoholic solution of resin mastic. This resembles a substance sold in the London shops, under the name of *diamond cement*. The recipe was given me by a respectable dispensing chemist.

AMORPHOUS. *Without shape.* Said of mineral and other substances which occur in forms not easy to be defined.

ANALYSIS. The art of resolving a compound substance or machine into its constituent parts. Every manufacturer should so study this art, in the proper treatises, and schools of Chemistry or Mechanics, as to enable him properly to understand and regulate his business.

ANCHOR. (*Ancre*, Fr.; *Anker*, Germ.) An iron hook of considerable weight and strength, for enabling a ship to lay hold of the ground, and fix itself in a certain situation by means of a rope called the cable. It is an instrument of the greatest importance to the navigator, since upon its taking and keeping hold depends his safety upon
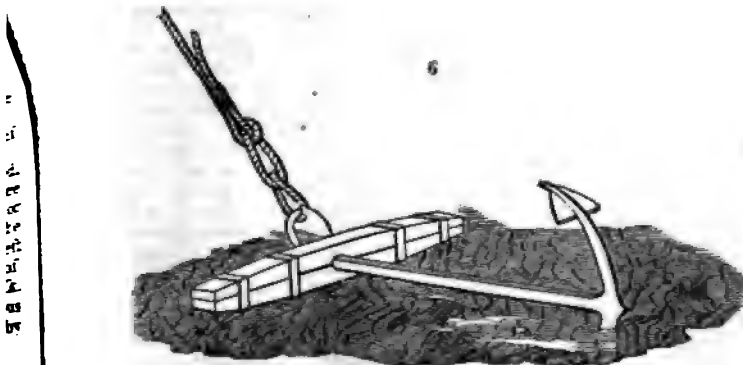
many occasions, especially near a lee shore, where he might be otherwise stranded or
shipwrecked. Anchors are generally made of wrought iron, except among nations who
cannot work this metal well, and who therefore use copper. The mode in which an
anchor operates will be understood from inspection of *fig.* 6, where, from the direction
of the strain, it is obvious that the anchor cannot move without ploughing up the
ground in which its hook or fluke is sunk. When this, however, unluckily takes
place, from the nature of the ground, from the mode of insertion of the anchor, or from
the violence of the winds or currents, it is called *dragging the anchor.* When the hold is
good, the cable or the buried arm will sooner break than the ship will drive. Anchors
are of different sizes, and have different names, according to the purposes they serve;
thus there are, *sheet, best bower, small bower, spare, stream,* and *kedge anchors.* Ships
of the first class have seven anchors, and smaller vessels, such as brigs and schooners,
three.
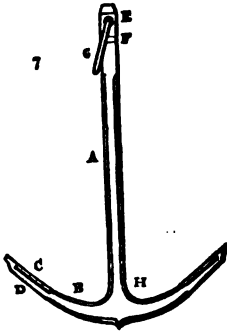
The manufacture of anchors requires great knowledge
of the structure of iron, and skill in the art of working
it. I shall give, here, a brief notice of the improved system
introduced by Mr. Perring, clerk of the cheque at Ply-
mouth, in which the proportions of the parts are admirably
adapted to the strains they are likely to suffer. In *fig.* 7,
A is the *shank ;* B, the *arm* or *fluke ;* C, the *palm ;* D, the
blade ; E, the *square ;* F, the *nut ;* G, the *ring ;* H, the *crown.*

Formerly the shank was made of a number of square
iron rods, laid parallel together in a cylindrical form, and
bound by iron hoops. When they were welded into one
bar, the exterior rods could not fail to be partially burned
and wasted by the strong heat. Mr. Perrin abated this
evil by using bars of the whole breadth of the shank, and
placing them right over each other, hooping them and
welding them together at two heats into one solid mass.
To any one who has seen the working of puddled iron, with
a heavy mill hammer, this operation will not appear difficult.

He formed the crown with bars similarly distributed with those of the shank. His
mode of uniting the flukes to the crown is probably the most valuable part of his
invention. The bars and half the breadth of the anchor are first welded separately, and
then placed side by side, where the upper half is worked into one mass, while the lower
part is left disunited, but has carrier iron bars, or *porters,* as these prolongation rods
are commonly called, welded to the extremity of each portion. The lower part is now
heated and placed in the clamping machine, which is merely an iron plate firmly bolted
to a mass of timber, and bearing upon its surface four iron pins. One end of the crown
is placed between the first of these pins, and passed under an iron strap; the other end
is brought between the other pins, and is bent by the leverage power of the elongated
rods or porters.

Thus a part of the arm being formed out of the crown gives much greater security
that a true union of fibres is effected, than when the junction was made merely by a short
scarf.

The angular opening upon the side opposite B H, *fig.* 7, is filled with the *chock,*
formed of short iron bars placed upright. When this has been firmly welded, the truss-
piece is brought over it. This piece is made of plates similar to the above, except that
their edges are here horizontal. The truss-piece is half the breadth of the arm ; so that,
when united to the crown, it constitutes, with the other parts, the total breadth of the
arms at those places.

The shank is now shut upon the crown; the square is formed, and the nuts welded to
it ; the hole is punched out for the ring, and the shank is then fashioned.

The blade is made much in the way above described. In making the palm, an iron
rod is first bent into the approximate form, notching it so that it may more readily take
the desired shape. To one end a *porter* rod is fastened, by which the palm is carried
and turned round in the fire during the progress of the fabrication. Iron plates are next
laid side by side upon the rod, and the joint at the middle is broken by another plate
laid over it. When the mass is worked, its under side is filled up by similar plates, and
the whole is completely welded ; pieces being added to the sides, if necessary, to form the
angles of the palm. The blade is then shut on to the palm, after which the part of the
arm attached to the blade is united to that which constitutes the crown. The smith-work
of the anchor is now finished.

The junction, or shutting on, as the workmen call it, of the several members of an
anchor, is effected by an instrument called a *monkey,* which is merely a mass of iron
raised to a certain height, between parallel uprights, as in the pile engine or vertical
ram, and let fall upon the metal previously brought to a welding heat.

The *monkey* and the *hercules*, both silly, trivial names, are similar instruments, and are usually worked, like a portable pile engine, by the hands of several laborers, pulling separate ropes. Many other modes of manufacturing anchors have been devised, in which mechanical power is more extensively resorted to.

The upper end of the shank F (*fig.* 7) is squared to receive and hold the stock steadily, and keep it from turning. To prevent it shifting along, there are two knobs or tenon-like projections. The point of the angle H, between the arms and the shank, is sometimes called the throat. The arm B c generally makes an angle of 56° with the shank A; it is either round or polygonal, and about half the length of the shank.

The *stock* of the anchor (*fig.* 6) is made of oak. It consists of two beams which embrace the *square*, and are firmly united by iron bolts and hoops, as shown in the figure. The stock is usually somewhat longer than the shank, has in the middle a thickness about one twelfth of its length, but tapers at its under side to nearly one half this thickness at the extremities. In small anchors the stock is frequently made of iron; but in this case it does not embrace the anchor, but goes through a hole made in the square, which is swelled out on purpose.

The weight of anchors for different vessels is proportioned to the tonnage; a good rule being to make the anchor in hundred weights one twentieth of the number of tons of the burden. Thus a ship of 1000 tons would require a sheet anchor of 50 cwts. Ships of war are provided with somewhat heavier anchors.

Several new forms and constructions of anchors were proposed under Mr. Piper's patent of November, 1822, by the adoption of which great advantages as to strength were anticipated over every other form or construction previously made.

The particular object was to preserve such a disposition of the fibres of the metal as should afford the greatest possible strength; in doing which the crossing or bending of the fibres at the junctions of the shank, flukes, and crown, where great strength is required, has been avoided as much as possible, so that the fibres are not disturbed or injured.

In this respect most anchors are defective; for in connecting the shanks to the crown-pieces, the grain of the metal is either crossed, or so much curved, as to strain the fibre, and consequently induce a weakness where the greatest strength is required. And, further, the very considerable thicknesses of metal which are to be brought into immediate contact by means of the hammer in forging anchors upon the old construction, render it highly probable that faulty places may be left within the mass, though they be externally imperceptible. Mr. Piper's leading principle was, that the fibre of the metal should run nearly straight in all the parts where strength is particularly required.
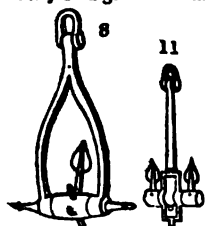
Fig. 8 shows an anchor with one tumbling fluke, which passes through the forked or branched part of the shank. The lower part of this anchor, answering to the crown, has a spindle through it, upon which the fluke turns, and a pin is there introduced for the purpose of confining the fluke when in a holding position. This shank is formed of a solid piece of wrought iron, the fibres of which run straight, and at the crown holes are pierced, which merely bulge the metal without bending the fibres round so as to strain them. The arm and fluke, also, are formed of one piece punched through without curling or crossing the fibre, and the spindle which holds the arm to the crown is likewise straight. This spindle extends some distance on each side of the anchor, and is intended to answer the purpose of a stock; for when either of the ends of the spindle comes in contact with the ground, the anchor will be thrown over into a holding position; or an iron stock may be introduced near the shackle, instead of these projecting ends. In the descent of the anchor, the fluke will fall over towards that side which is nearest the ground, and will there be ready to take hold when the anchor is drawn forward.
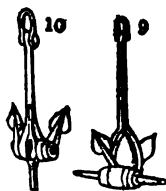

Fig. 9 is another anchor upon the same principle, but slightly varied in form from the last. In this the forked part of the shank is closer than in the former, and there are two arms or flukes connected to the crown-pieces, one of which falls into its holding position as the anchor comes to the ground, and is held at its proper angle by the other fluke stopping against the shank.

Fig. 10 represents another variation in the form of these improved anchors, having two tumbling flukes, which are both intended to take hold of the ground at the same time. The shank is here, as before, made without crossing the grain of the iron, and the eyes for admitting the bolt at the crown and at the shackle are punched out of the solid, not formed by welding or turning the iron round. In this form a guard is introduced at

the crown, to answer the purpose of a stock, by turning the flukes over into a holding position. The arms and flukes are made, as before described, of the straight fibre of the iron punched through, and the flukes are fixed to the spindle, which passes through the crown-piece.

Fig. 11 has a shank without any fork, but formed straight throughout; the guard here is an elongated frame of iron, for the same purpose as a stock, and is, with the tumbling flukes, fastened to the spindle, which passes through the crown of the anchor, and causes the flukes to fall into their holding position.

The principles of these new anchors are considered to consist in shanks which are made of straight lengths of metal, and finished so that the fibres of the iron shall not be injured by cross-shuts or uncertain welding; also each arm and palm is made in one solid piece, and finished in straight lines, so that the fibres will not be altered, and the shaft-pin or spindle will also be in one straight line; and this is the improvement claimed. These anchors, being made in separate pieces, give a great advantage to the workman to execute each part perfectly; for he will not have such heavy weights to lift when hot, which will render these anchors much stronger, with less weight; and if any accident should happen to them, any part may be taken separate from the others to be repaired, and several of those parts of the anchor which may be likely to break may be carried on board, in case of accident. This anchor is so contrived that one of thirty hundred weight may be taken to pieces and put together again, by one man, in twenty minutes; it may also be dismounted, and stowed in any part of the ship, in as little room as straight bars of iron, and speedily put together again.
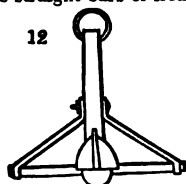
The anchor (*fig.* 12) patented by Mr. Brunton, in February, 1822, has its stock introduced at the crown part, for the purpose of turning it over into a holding position. The shank is perforated through the solid, in two places, with elliptical apertures, for the purpose of giving it a greater stability, and more effectually resisting the strain to which the anchor may be subjected. The stock is a cylindrical iron rod, held at its extremities by lateral braces, which are bolted to the shank.

Fig. 12 shows the form of the anchor. The shank is seen upright, with one of the flukes projecting in its front; the horizontal iron stock is at bottom; and the oblique braces are bolted to both shank and stock. The ends of the stock, from the shoulder, are formed dove-tailed, and oval in the vertical direction, and are protruded through apertures in the braces, also oval, but in the horizontal direction, and counter sunk. When the ends of the stock have been thus introduced through the holes, the braces are securely bolted to the shank, the ends of the stock are then spread, by hammering into the counter-sunk holes of the braces, and by that means they are made firm.

An anchor of this description is considered by the patentee to possess considerable advantage, particularly in point of stability, over the ordinary construction of anchors, and is economical, inasmuch as a less weight of metal will give, upon this plan, an equal degree of strength.

An ingenious form of anchor was made the subject of a patent, by Lieutenant Rodgers, of the Royal Navy, in 1828, and was afterwards modified by him in a second patent, obtained in August, 1829. The whole of the parts of the anchor are to be bound together by means of iron bands or hoops, in place of bolts or pins.

Fig. 13 is a side view of a complete anchor, formed upon his last improved construction, and *fig.* 14, a plan of the same; *fig.* 15, an end view of the crown and flukes, or arms; *fig.* 16 represents the two principal iron plates, *a*, *a*, of

which the shank is constructed, but so as to form parts of the stump arms to which the flukes are to be connected.

The crown piece is to be welded to the stump piece, *c*, *c*, *fig.* 16, as well as to the
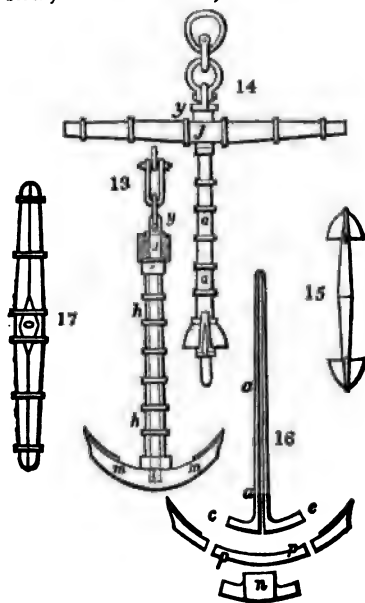
end *l* of the centre piece *h h*, and the scarfs *m m* are to be cut to receive the arms or flukes. Previously, however, to uniting the arms or flukes with the stump arms, the crown and throat of the anchor are to be strengthened, by the application of the crown slabs *n n*, *fig.* 16, which are to be welded upon each side of the crown, overlapping the end of the pillar *h*, and the throat or knees of the stump arms and the crown piece. The stump arms are then to be strengthened in a similar manner, by the thin flat pieces *p p*, which are to be welded upon each side. The palms are united to the flukes in the usual way, and the flukes are also united to the stump arms by means of the long scarfs *m m*. When the shank of the anchor has been thus formed, and united with the flukes, the anchor smith's work may be said to be complete.

Another of the improvements in the construction of anchors, claimed under this patent, consists in a new method of affixing the stock upon the shank of the anchor, which is effected in the following manner : in *fig.* 14, the stock is shown affixed to the anchor; in *fig.* 17, it is shown detached. It may be made either of one or two pieces of timber, as may be found most convenient. It is, however, to be observed that the stock is to be completed before fitting on to the shank. After the stock is shaped, a hole is to be made through the middle of it, to fit *that* part of the shank to which it is to be affixed. Two stock plates are then to be let in, one on each side of the stock, and made fast by counter sunk nails and straps, or hoops; other straps or hoops of iron are also to be placed round the stock, as usual,

In place of nuts, formed upon the shank of the anchor, it is proposed to secure the stock by means of a hoop and a key, shown above and below *s*, in *fig.* 14. By this contrivance, the stock is prevented from going nearer to the crown of the anchor than it ought to do, and the key prevents it from sliding towards the shackle.

Since fitting the stock to the shank of an anchor, by this method, prevents the use of a ring, as in the ordinary manner, the patentee says that he in all cases substitutes a shackle for the ring, and which is all that is required for a chain cable; but, when a hempen cable is to be used, he connects a ring to the usual shackle, by means of a joining shackle, as in *figs.* 13 and 14.

Mr. Rodgers proposes, under another patent, dated July, 1833, to alter the size and form of the palms; having found from experience that anchors with small palms will not only hold better than with large ones, but that the arms of the anchor, even without any palms, have been found to take more secure hold of the ground than anchors of the old construction, of similar weight and length. He has, accordingly, fixed upon one-fifth of the length of the arm, as a suitable proportion for the length or depth of the palm. He makes the palms, also, broader than they are long or deep.

ANIME'. A resin of a pale brown yellow color, transparent and brittle. It exudes from the courbaril of Cayenne, a tree which grows also in various parts of South America. It occurs in pieces of various sizes, and it often contains so many insects belonging to living species, as to have merited its name, as being animated. It contains about a fifth of one per cent. of a volatile oil, which gives it an agreeable odor. Alcohol does not dissolve the genuine animé, as I have ascertained by careful experiments; nor does caoutchoucine; but a mixture of the two, in equal parts, softens it into a tremulous jelly, though it will not produce a liquid solution. When reduced to this state, the insects can be easily picked out, without injury to their most delicate parts.

The specific gravity of the different specimens of animé which I tried, varied from 1·054 to 1·057. When exposed to heat, in a glass retort over a spirit flame, it softens, and, by careful management, it may be brought into liquid fusion, without discoloration. It then exhales a few white vapors, of an ambrosiacal odor, which being condensed in water, and the liquid being tested, is found to be succinic acid. *Author.*

It is extensively used by the varnish makers, who fuse it at a pretty high heat, and in this state combine it with their oils, or other varnishes.

ANKER. A liquid measure of Amsterdam, which contains 32 gallons English.

ANNEALING or NEALING. (*Le recuit*, Fr.; *das anlassen*, Germ.) A process by which glass is rendered less frangible; and metals, which have become brittle, either in consequence of fusion, or long-continued hammering, are again rendered malleable. When a glass vessel is allowed to cool immediately after being made, it will often sustain the shock of a pistol-bullet, or any other blunt body falling into it from a considerable height; while a small splinter of flint, or an angular fragment of quartz, dropped gently into it, makes it sometimes immediately, sometimes after a few minutes, fly to pieces with great violence. This extreme fragility is prevented by annealing, or placing the vessels in an oven, where they take several hours or even some days to cool. Similar phenomena are exhibited in a higher degree by glass-tears, or Prince Rupert's drops. They are procured by letting drops of melted glass fall into cold water. Their form resembles that of a pear, rounded at one extremity, and tapering to a very slender tail at the other. If a part of the tail be broken off, the whole drop flies to pieces with a loud explosion; and yet the tail of a drop may be cut away by a glass-cutter's wheel, or the thick end

may be struck smartly with a hammer, without the fear of sustaining any injury. When heated to redness, and permitted to cool gradually in the open air, they lose these peculiarities, and do not differ sensibly from common glass.

The properties of unannealed glass depend on a peculiar structure, extending uniformly through its whole substance; and the bursting of a glass drop by breaking off the tail, or of an unannealed glass vessel, by dropping a piece of flint into it, arises from a crack being thus begun, which afterwards extends its ramifications in different directions throughout the glass.

When metals have been extended to a certain degree under the hammer, they become brittle, and incapable of being further extended without cracking. In this case the workman restores their malleability by annealing, or heating them red-hot. The rationale of this process seems to be, that the hammering and extension of the metal destroy the kind of arrangement which the particles of the metal had previous to the hammering; and that the annealing, by softening the metal, enables it to recover its original structure.

Of late years a mode has been discovered of rendering cast iron malleable, without subjecting it to the action of puddling. The process is somewhat similar to that employed in annealing glass. The metal is kept for several hours at a temperature a little below its fusing point, and then allowed to cool slowly. In this manner vessels are made of cast iron which can sustain considerable violence, without being broken. See Steel, softening of.

ANNOTTO. (*Rocou*, or *roucou*, Fr.; *orleans*, Germ.) A somewhat dry and hard paste, brown without, and red within. It is usually imported in cakes of two or three pounds weight, wrapped up in leaves of large reeds, packed in casks, from America, where it is prepared from the seeds of a certain tree, the *bixa orellana*, of Linnæus.

The pods of the tree being gathered, their seeds are taken out and bruised; they are then transferred to a vat, which is called the steeper, where they are mixed with as much water as covers them. Here the substance is left for several weeks, or even months; it is now squeezed through sieves placed above the steeper, that the water containing the coloring matter in suspension may return into the vat. The residuum is preserved under the leaves of the anana (pine-apple) tree, till it becomes hot by fermentation. It is again subjected to the same operation, and this treatment is continued till no more color remains.

The substance thus extracted is passed through sieves, in order to separate the remainder of the seeds, and the color is allowed to subside. The precipitate is boiled in coppers till it be reduced to a consistent paste; it is then suffered to cool, and dried in the shade.

Instead of this long and painful labor, which occasions diseases by the putrefaction induced, and which affords a spoiled product, Leblond proposes simply to wash the seeds of annotto till they be entirely deprived of their color, which lies wholly on their surface; to precipitate the color by means of vinegar or lemon juice, and to boil it up in the ordinary manner, or to drain it in bags, as is practised with indigo.

The experiments which Vauquelin made on the seeds of annotto imported by Leblond, confirmed the efficacy of the process which he proposed; and the dyers ascertained that the annotto obtained in this manner was worth at least four times more than that of commerce; that, moreover, it was more easily employed; that it required less solvent; that it gave less trouble in the copper, and furnished a purer color.

Annotto dissolves better and more readily in alcohol than in water, when it is introduced into the yellow varnishes for communicating an orange tint.

The decoction of annotto in water has a strong peculiar odor, and a disagreeable taste. Its color is yellowish-red, and it remains a little turbid. An alkaline solution renders its orange-yellow clearer and more agreeable, while a small quantity of a whitish substance is separated from it, which remains suspended in the liquid. If annotto be boiled in water along with an alkali, it dissolves much better than when alone, and the liquid has an orange hue.

The acids form with this liquor an orange-colored precipitate, soluble in alkalies, which communicate to it a deep orange color. The supernatant liquor retains only a pale yellow hue.

When annotto is used as a dye, it is always mixed with alkali, which facilitates its solution, and gives it a color inclining less to red. The annotto is cut in pieces, and boiled for some instants in a copper with its own weight of crude pearl ashes, provided the shade wanted do not require less alkali. The cloths may be thereafter dyed in this bath, either by these ingredients alone, or by adding others to modify the color; but annotto is seldom used for woollen, because the colors which it gives are too fugitive, and may be obtained by more permanent dyes. Hellot employed it to dye a stuff, prepared with alum and tartar; but the color acquired had little permanence. It is almost solely used for silks.

For silks intended to become aurora and orange, it is sufficient to scour them at the rate of 20 per cent. of soap. When they have been well cleansed, they are immersed in a bath prepared with water, to which is added a quantity of alkaline solution of annotto, more or less considerable according to the shade that may be wanted. This bath should have a mean temperature, between that of tepid and boiling water.

When the silk has become uniform, one of the hanks is taken out, washed, and wrung, to see if the color be sufficiently full; if it be not so, more solution of annotto is added, and the silk is turned again round the sticks : the solution keeps without alteration.

When the desired shade is obtained, nothing remains but to wash the silk, and give it two beetlings at the river, in order to free it from the redundant annotto, which would injure the lustre of the color.

When raw silks are to be dyed, those naturally white are chosen, and dyed in the annotto bath, which should not be more than tepid, or even cold, in order that the alkali may not attack the gum of the silk, and deprive it of the elasticity which it is desirable for it to preserve.

What has been now said regards the silks to which the aurora shades are to to be given ; but to make an orange hue, which contains more red than the aurora, it is requisite, after dyeing with annotto, to redden the silks with vinegar, alum, or lemon juice. The acid, by saturating the alkali employed for dissolving the annotto, destroys the shade of yellow that the alkali had given, and restores it to its natural color, which inclines a good deal to red.

For the deep shades, the practice at Paris, as Macquer informs us, is to pass the silks through alum; and if the color be not red enough, they are passed through a faint bath of brazil wood. At Lyons, the dyers who use carthamus, sometimes employ old baths of this ingredient for dipping the deep oranges.

When the orange hues have been reddened by alum, they must be washed at the river; but it is not necessary to beetle them, unless the color turns out too red.

Shades may be obtained also by a single operation, which retain a reddish tint, employing for the annotto bath a less proportion of alkali than has been pointed out.

Guhliche recommends to avoid heat in the preparation of annotto. He directs it to be placed in a glass vessel, or in a glazed earthen one; to cover it with a solution of pure alkali; to leave the mixture at rest for 24 hours; to decant the liquor, filter it, and add water repeatedly to the residuum, leaving the mixture each time at rest for two or three days, till the water is no longer colored ; to mix all these liquors, and preserve the whole for use in a well-stopped vessel.

He macerates the silk for 12 hours in a solution of alum, at the rate of an eighth of this salt for one part of silk, or in a water rendered acidulous by the aceto-citric acid above described; and he wrings it well on its coming out of this bath

Silk thus prepared is put into the annotto bath quite cold. It is kept in agitation there till it has taken the shade sought for; or the liquor may be maintained at a heat far below ebullition. On being taken out of the bath, the silk is to be washed and dried in the shade.

For lighter hues, a liquor less charged with color is taken ; and a little of the acid liquid which has served for the mordant may be added, or the dyed silk may be passed through the acidulous water.

We have seen the following preparation employed for cotton velvet :—one part of quicklime, one of potash, two of soda.

Of these a ley is formed, in which one part of annotto is dissolved; and the mixture is boiled for an hour and a half. This bath affords the liveliest and most brilliant auroras. The buff (chamois) fugitive dye is also obtained with this solution. For this purpose only a little is wanted; but we must never forget, that the colors arising from annotto are all fugitive.

Dr. John found in the pulp surrounding the unfermented fresh seeds, which are about the size of little peas, 28 parts of coloring resinous matter, 26·5 of vegetable gluten, 20 of ligneous fibre, 20 of coloring extractive matter, 4 formed of matters analogous to vegetable gluten and extractive, and a trace of spicy and acid matters.

The Gloucestershire cheese is colored with annotto, in the proportion of one cwt. to an ounce of the dye.

When used in calico-printing, it is usually mixed with potash or ammonia and starch. It is an appropriate substance for tinging varnishes, oils, spirits, &c.

The import duty upon annotto is 1s. per cwt. for flag, and 4s. for other sorts. In 1834, 252,981 lbs. were imported ; and in 1835, 163,421 lbs. The revenue from this drug in these two years, was 180l. and 98l. respectively.

ANTHRACITE, from ανθραξ, coal, is a species of coal found in the transition rock formation, and is often called stone coal. It has a grayish black, or iron black color, a imperfectly metallic lustre, conchoidal fracture, and a specific gravity of from 1·4 to 1·6, being therefore, much denser than the coal of the proper coal measures. It consists

wholly of carbon, with a small and variable proportion of iron, silica, and alumina. It is difficult to kindle in separate masses, and burns when in heaps or grates without smell or smoke, leaving sometimes an earthy residuum. It has been little explored or worked in the old world; but is extensively used in the United States of America, and has become of late years a most valuable mineral to that country, where it is burned in peculiar grates, adapted to its difficult combustion. In Pennsylvania the anthracite coal formation has been traced through a tract many miles in width, and extending across the two entire counties of Luzerne and Schuylkill. At Maunch Chunk, upon the Lehigh, 800 men were employed, so far back as 1825, in digging this coal. In that year 750,000 bushels were despatched for Philadelphia. It is worked there with little cost or labor, being situated on hills from 300 to 600 feet above the level of the neighboring rivers and canals, and existing in nearly horizontal beds, of from 15 to 40 feet in thickness, covered by only a few feet of gravelly loam. At Portsmouth, in Rhode Island, an extensive stratum of this coal has been worked, with some interruptions, for 20 years; and more recently a mine of anthracite has been opened at Worcester, in Massachusetts, at the head of the Blackstone canal. It has been of late employed in South Wales, for smelting iron, and in a cupola blast furnace, by Mr. Crane.

ANTIGUGGLER. A small syphon of metal, which is inserted into the mouths of casks, or large bottles, called carboys, to admit air over the liquor contained in them, and thus to facilitate their being emptied without agitation or a guggling noise.

ANTIMONY. (*Antimoine*, Fr.; *Spiessglanz*, or *Spiessglass*, Ger.) The only ore of this metal found in sufficient abundance to be smelted, is the sulphuret, formerly called crude antimony. It occurs generally in masses, consisting of needles closely aggregated, of a metallic lustre, a lead-gray color, inclining to steel-gray, which is unchanged in the streak. The needles are extremely brittle, and melt even in the flame of a candle, with the exhalation of a sulphureous smell. The powder of this sulphuret is very black, and was employed by women in ancient times to stain their eyebrows and eyelids. This ore consists in 100 parts of 72·86 metal, and 27·14 sulphur. Specific gravity from 4·13 to 4·6.

The veins of sulphuret of antimony occur associated with gangues of quartz, sulphate of barytes, and carbonate of lime; those of Allemont occur in the numerous fissures of a mica schist, evidently primitive.

In treating the ore to obtain the metal, the first object is to separate the gangue, which was formerly done by filling crucibles with the mixed materials, placing them on the hearth of an oven, and exposing them to a moderate heat. As the sulphuret easily melts, it ran out through a hole in the bottom of the crucible into a pot placed beneath, and out of the reach of the fire. But the great loss from breakage of the crucibles, has caused another method to be adopted. In this the broken ore, being sorted, is laid on the bottom of a concave reverberatory hearth, where it is reduced.

Figs. 18, 19, represent a wind or flame furnace, for the reduction of antimony. The
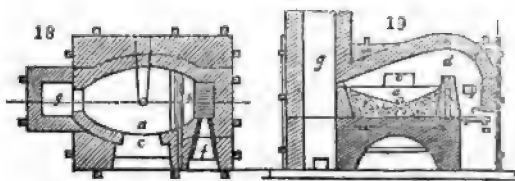
hearth is formed of sand and clay solidly beat together, and slopes from all sides towards the middle, where it is connected with the orifice *a*, which is closed with dense coal-ashes; *b* is the air channel up through the bridge; *c*, the door for introducing the prepared ore, and running off the slags; *d*, the bridge; *e*, the grate; *f*, the fire or fuel door; *g*, the chimney. With 2 or 3 cwt. of ore, the smelting process is completed in from 8 to 10 hours. The metal thus obtained is not pure enough, but must be fused under coal dust, in portions of 20 or 30 pounds, in crucibles, placed upon a reverberatory hearth.

To obtain antimony free from iron, it should be fused with some antimonic oxyde in a crucible, whereby the iron is oxydized and separated. The presence of arsenic in antimony is detected by the garlic smell, emitted by such an alloy when heated at the blow-pipe; or, better, by igniting it with nitre in a crucible; in which case, insoluble antimonite and antimoniate of potash will be formed along with soluble arseniate. Water digested upon the mixture, filtered, and then tested with nitrate of silver, will afford the brown-red precipitate characteristic of arsenic acid.

According to Berthier, the following materials afford, in smelting, an excellent product of antimony: 100 parts of sulphuret; 60 of hammerschlag (protoxyde of iron from the shingling or rolling mills); 45 to 50 of carbonate of soda; and 10 of charcoal powder. From 65 to 70 parts of metallic antimony or regulus should be obtained. Glauber salts may be used instead of soda. For another mode of smelting antimony, at Malbose, in the department of Ardèche, in France, see LIQUATION.

In the works where antimonial ores are smelted, by means of tartar (argol), the alka-

line scoriæ, which cover the metallic ingots, are not rejected as useless, for they hold a certain quantity of antimonial oxyde in combination; a property of the potash flux, which is propitious to the purity of the metal. These scoriæ, consisting of sulphuret of potassium and antimonite of potash, being treated with water, undergo a reciprocal decomposition; the elements of the water act on those of the sulphuret, and the resulting alkaline hydro-sulphuret reacts on the antimonial solution, so as to form a species of *kermes mineral*, which precipitates. This is dried, and sold at a low price as a veterinary medicine, under the name of *kermes*, by the dry way.

Metallic antimony, as obtained by the preceding process, is the antimony of commerce, but is not absolutely pure; containing frequently minute portions of iron, lead, and even arsenic; the detection and separation of which belong to the sciences of chemistry and pharmacy. Antimony is a brittle metal, of a silvery white color, with a tinge of blue, a lamellar texture, and crystalline fracture. When heated at the blow-pipe, it melts with great readiness, and diffuses white vapors, possessing somewhat of a garlic smell. If thrown in this melted state on a sheet of flat paper, the globule sparkles, and bursts into a multitude of small spheroids, which retain their incandescence for a long time, and run about on the paper, leaving traces of the white oxyde produced during the combustion. When this oxyde is fused with borax, or other vitrifying matter, it imparts a yellow color to it. Metallic antimony, treated with hot nitric acid and in a concentrated state, is converted into a powder, called antimonious acid, which is altogether insoluble in the ordinary acid menstrua; a property by which the chemist can separate that metal from lead, iron, copper, bismuth, and silver. According to Bergman, the specific gravity of antimony is 6·86; but Haidinger makes the Swedish native metal only 6·646. The alchemists had conceived the most brilliant hopes of this metal. The facility with which it is alloyed with gold, since its fumes alone render this most ductile metal immediately brittle, led them to assign to it a royal lineage, and to distinguish it by the title of *regulus*, or the little king.

Its chief employment now is in medicine, and in making the alloys called type metal, stereotype metal, music plates, and Britannia metal; the first consisting of 6 of lead and 2 of antimony; the second of 6 of lead and 1 of antimony; the third of lead, tin, and antimony; and the fourth also of lead, tin, and antimony, with occasionally a little copper and bismuth.—For Glass of antimony, see PASTES.

ANTISEPTICS. Substances which counteract the spontaneous decomposition of animal and vegetable substances. These are chiefly culinary salt, nitre, spices, and sugar, which operate partly by inducing a change in the animal or vegetable fibres, and partly by rendering the aqueous constituent unsusceptible of decomposition. See PROVISIONS, CURING OF.

ANVIL. A mass of iron, having a smooth and nearly flat top surface of steel; upon which blacksmiths, and various other artificers, forge metals with the hammer. The common anvil is usually made of seven pieces: 1, the core, or body; 2, 3, 4, 5, the four corner pieces which serve to enlarge its base; 6, the projecting end, which has a square hole for the reception of the tail or shank of a chisel on which iron bars may be cut through; and 7, the beak, or horizontal cone round which rods or slips of metal may be turned into a circular form, as in making rings. These 6 pieces are welded separately to the first, or core, and then hammered into a uniform body. In manufacturing large anvils two hearths are needed, in order to bring each of the two pieces to be welded, to a proper heat by itself; and several men are employed in working them together briskly in the welding state, by heavy swing hammers. The steel facing is applied by welding in the same manner. The anvil is then hardened by heating it to a cherry red, and plunging it into cold water; a running stream being preferable to a pool or cistern. The facing should not be too thick a plate, for, when such, it is apt to crack in the hardening. The face of the anvil is now smoothed upon a grindstone, and finally polished with emery and crocus, for all delicate purposes of art.

The blacksmith, in general, sets his anvil loosely upon a wooden block, and in preference on the root of an oak. But the cutlers and file-makers fasten their anvils to a large block of stone, which is an advantage, for the more firmly and solidly this tool is connected to the earth, the more efficacious will be the blows with the hammer on any object placed upon it.

AQUAFORTIS. Nitric acid, somewhat dilute, was so named by the alchemists on account of its strong solvent and corrosive operation upon many mineral, vegetable, and animal substances. See NITRIC ACID.

AQUA REGIA. The name given by the alchemists to that mixture of nitric and muriatic acids which was best fitted to dissolve gold, styled by them the king of the metals. It is now called *nitro-muriatic acid*.

AQUA VITÆ. The name very absurdly given to alcohol, when used as an intoxicating beverage. It has been the *aqua mortis* to myriads of the human race; and will, probably, ere long destroy all the native tribes of North America and Australia.

ARCHIL. A violet red paste used in dyeing, of which the substance called *cudbear* in Scotland (from *Cuthbert*, its first preparer in that form), is a modification. Two kinds of archil are distinguished in commerce, the *archil* plant of the Canaries, and that of Auvergne. The first is most esteemed: it is prepared from the *lichen rocellus*, which grows on rocks adjoining the sea in the Canary and Cape de Verd Islands, in Sardinia, Minorca, &c., as well as on the rocks of Sweden. The second species is prepared from the *lichen parellus*, which grows on the basaltic rocks of Auvergne.

There are several other species of lichen which might be employed in producing an analogous dye, were they prepared, like the preceding, into the substance called *archil*. Hellot gives the following method for discovering if they possess this property. A little of the plant is to be put into a glass vessel; it is to be moistened with ammonia and lime-water in equal parts; a little muriate of ammonia (sal ammoniac) is added; and the small vessel is corked. If the plant be of a nature to afford a red dye, after three or four days, the small portion of liquid, which will run off on inclining the vessel, now opened, will be tinged of a crimson red, and the plant itself will have assumed this color. If the liquor or the plant does not take this color, nothing need be hoped for; and it is useless to attempt its preparation on the great scale. Lewis says, however, that he has tested in this way a great many mosses, and that most of them afforded him a yellow or reddish-brown color; but that he obtained from only a small number a liquor of a deep red, which communicated to cloth merely a yellowish-red color.

Prepared archil gives out its color very readily to water, ammonia, and alcohol. Its solution in alcohol is used for filling spirit-of-wine thermometers; and when these thermometers are well freed from air, the liquor loses its color in some years, as Abbé Nollet observed. The contact of air restores the color, which is destroyed anew, in vacuo, in process of time. The watery infusion loses its color, by the privation of air, in a few days; a singular phenomenon, which merits new researches.

The infusion of archil is of a crimson bordering on violet. As it contains ammonia, which has already modified its natural color, the fixed alkalies can produce little change on it, only deepening the color a little, and making it more violet. Alum forms in it a precipitate of a brown red; and the supernatant liquid retains a yellowish-red color. The solution of tin affords a reddish precipitate, which falls down slowly; the supernatant liquid retains a feeble red color. The other metallic salts produce precipitates which offer nothing remarkable.

The watery solution of archil, applied to cold marble, penetrates it, communicating a beautiful violet color, or a blue bordering on purple, which resists the air much longer than the archil colors applied to other substances. Dufay says, that he has seen marble tinged with this color preserve it without alteration at the end of two years.

To dye with archil, the quantity of this substance deemed necessary, according to the quantity of wool or stuff to be dyed, and according to the shade to which they are to be brought, is to be diffused in a bath of water as soon as it begins to grow warm. The bath is then heated till it be ready to boil, and the wool or stuff is passed through it without any other preparation, except keeping that longest in, which is to have the deepest shade. A fine gridelin, bordering upon violet, is thereby obtained; but this color has no permanence. Hence archil is rarely employed with any other view than to modify, heighten, and give lustre to the other colors. Hellot says, that having employed archil on wool boiled with tartar and alum, the color resisted the air no more than what had received no preparation. But he obtained from herb archil (*l'orseille d'herbe*) a much more durable color, by putting in the bath some solution of tin. The archil thereby loses its natural color, and assumes one approaching more or less to scarlet, according to the quantity of solution of tin employed. This process must be executed in nearly the same manner as that of scarlet, except that the dyeing may be performed in a single bath.

Archil is frequently had recourse to for varying the different shades and giving them lustre; hence it is used for violets, lilachs, mallows, and rosemary flowers. To obtain a deeper tone, as for the deep *soupes au vin*, sometimes a little alkali or milk of lime is mixed with it. The suites of this browning may also afford agates, rosemary flowers, and other delicate colors, which cannot be obtained so beautiful by other processes. Alum cannot be substituted for this purpose; it not only does not give this lustre, but it degrades the deep colors.

The herb-archil is preferable to the archil of Auvergne, from the greater bloom which it communicates to the colors, and from the larger quantity of coloring matter. It has, besides, the advantage of bearing ebullition. The latter, moreover, does not answer with alum, which destroys the color; but the herb archil has the inconvenience of dyeing in an irregular manner, unless attention be given to pass the cloth through hot water as soon as it comes out of the dye.

Archil alone is not used for dyeing silk, unless for lilachs; but silk is frequently passed through a bath of archil, either before dyeing it in other baths or after it has been dyed, in order to modify different colors, or to give them lustre. Examples of this

will be given in treating of the compound colors. It is sufficient here to point out how white silks are passed through the archil bath. The same process is performed with a bath more or less charged with this color, for silks already dyed.

Archil, in a quantity proportioned to the color desired, is to be boiled in a copper. The clear liquid is to be run off quite hot from the archil bath, leaving the sediment at the bottom, into a tub of proper size, in which the silks, newly scoured with soap, are to be turned round on the skein-sticks with much exactness, till they have attained the wished-for shade. After this they must receive one beetling at the river.

Archil is in general a very useful ingredient in dyeing; but as it is rich in color, and communicates an alluring bloom, dyers are often tempted to abuse it, and to exceed the proportions that can add to the beauty without at the same time injuring in a dangerous manner the permanence of the colors. Nevertheless, the color obtained when solution of tin is employed, is less fugitive than without this addition: it is red, approaching to scarlet. Tin appears to be the only ingredient which can increase its durability. The solution of tin may be employed, not only in the dyeing bath, but for the preparation of the silk. In this case, by mixing the archil with other coloring substances, dyes may be obtained which have lustre with sufficient durability.

We have spoken of the color of the archil as if it were natural to it; but it is, really, due to an alkaline combination. The acids make it pass to red, either by saturating the alkali, or by substituting themselves for the alkali.

The lichen which produces archil is subjected to another preparation, to make turnsole (litmus). This article is made in Holland. The lichen comes from the Canary Islands, and also from Sweden. It is reduced to a fine powder by means of a mill, and a certain proportion of potash is mixed with it. The mixture is watered with urine, and allowed to suffer a species of fermentation. When this has arrived at a certain degree, carbonate of lime in powder is added, to give consistence and weight to the paste, which is afterwards reduced into small parallelopipeds that are carefully dried.

The latest researches on the lichens, as objects of manufacture, are those of Westring of Stockholm. He examined 150 species, among which he found several which might be rendered useful. He recommends that the coloring matter should be extracted in the places where they grow, which would save a vast expense in curing, package, carriage, and waste. He styles the coloring substance itself cutbear, persio, or turnsole; and distributes the lichens as follows :—1st. Those which, left to themselves, exposed to moderate heat and moisture, may be fixed without a mordant upon wool or silk; such are the L. *cinereus, æmatonia, ventosus, corallinus, westringii, saxatilis, conspassus, barbatus, plicatus, vulpinus*, &c.

2. Those which develop a coloring matter, fixable likewise without mordant, but which require boiling and a complicated preparation; such are the lichens *subcarneus, dillenii, farinaceus, jubatus, furfuraceus, pulmonareus, cornigatus, cocciferus, digitatus, ancialis, aduncus*, &c. Saltpetre or sea-salt is requisite to improve the lustre and fastness of the dye given by this group to silk.

3. Those which require a peculiar process to develop their color; such as those which become purple through the agency of stale urine or ammonia. Westring employed the following mode of testing :—He put three or four drachms of the dried and powdered lichen into a flask; moistened it with three or four measures of cold spring water; put the stuff to be dyed into the mixture, and left the flask in a cool place. Sometimes he added a little salt, saltpetre, quicklime, or sulphate of copper. If no color appeared, he then moistened the lichen with water containing one twentieth of sal ammoniac, and one tenth of quicklime, and set the mixture aside in a cool place from eight to fourteen days. There appeared in most cases a reddish or violet colored tint. Thus the *lichen cinereus* dyed silk a deep carmelite, and wool a light carmelite; the *l. physodes* gave a yellowish-gray; the *pustulatus*, a rose red; *sanguinarius*, gray; *tartareus*, found on the rocks of Norway, Scotland, and England, dyes a crimson-red. In Jutland, cutbear is made from it, by grinding the dry lichen, sifting it, then setting it to ferment in a close vessel with ammonia. The lichen must be of the third year's growth to yield an abundant dye; and that which grows near the sea is the best. It loses half its weight by drying. A single person may gather from twenty to thirty pounds a day in situations where it abounds. No less than 2,239,685 pounds were manufactured at Christiansand, Flekkefiort, and Fakrsund, in Norway, in the course of the six years prior to 1812. Since more solid dyes of the same shade have been invented, the archil has gone much into disuse. Federigo, of Florence, who revived its use at the beginning of the fourteenth century, made such an immense fortune by its preparation, that his family became one of the grandees of that city, under the name of Oricellarii, or Rucellarii. For more than a century Italy possessed the exclusive art of making archil, obtaining the lichens from the islands of the Mediterranean. According to an official report of 1831, Teneriffe furnished annually 500 quintals (cwts.) of lichen;

the Canary Isles, 400; Fuerta Santura, 300; Lancerot, 300; Gomera, 300; isle of Ferro, 800. This business belonged to the crown, and brought it a revenue of 1500 piastres. The farmers paid from 15 to 20 reals for the right to gather each quintal. At that time the quintal fetched in the London market 4l. sterling.

Archil is perhaps too much used in some cloth factories of England, to the discredit of our dyes. It is said, that by its aid one third of the indigo may be saved in the blue vat; but the color is so much the more perishable. The fine soft tint induced upon much of the black cloth by means of archil is also deceptive. One half-pound of cutbear will dye one pound of woollen cloth. A crimson red is obtained by adding to the decoction of archil a little salt of tin (muriate), and passing the cloth through the bath, after it has been prepared by a mordant of tin and tartar. It must be afterwards passed through hot water.

ARDENT SPIRIT. Alcohol of moderate strength.

AREOMETER OF BAUME'. This scale is much used by the French authors.

Specific Gravity Numbers corresponding with Baumé's Areometric Degrees.

Liquids denser than Water.						Less dense than Water.			
De-grees.	Specific gravity.	De-grees.	Specific gravity.	De-grees.	Specific gravity.	De-grees.	Specific gravity.	De-grees.	Specific gravity.
0	1·0000	26	1·2063	52	1·5200	10	1·0000	36	0·8488
1	1·0066	27	1·2160	53	1·5353	11	0·9932	37	0·8439
2	1·0133	28	1·2258	54	1·5510	12	0·9865	38	0·8391
3	1·0201	29	1·2358	55	1·5671	13	0·9799	39	0·8343
4	1·0270	30	1·2459	56	1·5833	14	0·9733	40	0·8295
5	1·0340	31	1·2562	57	1·6000	15	0·9669	41	0·8249
6	1·0411	32	1·2667	58	1·6170	16	0·9605	42	0·8202
7	1·0483	33	1·2773	59	1·6344	17	0·9542	43	0·8156
8	1·0556	34	1·2881	60	1·6522	18	0·9480	44	0·8111
9	1·0630	35	1·2992	61	1·6705	19	0·9420	45	0·8066
10	1·0704	36	1·3103	62	1·6889	20	0·9359	46	0·8022
11	1·0780	37	1·3217	63	1·7079	21	0·9300	47	0·7978
12	1·0857	38	1·3333	64	1·7273	22	0·9241	48	0·7935
13	1·0935	39	1·3451	65	1·7471	23	0·9183	49	0·7892
14	1·1014	40	1·3571	66	1·7674	24	0·9125	50	0·7849
15	1·1095	41	1·3694	67	1·7882	25	0·9068	51	0·7807
16	1·1176	42	1·3818	68	1·8095	26	0·9012	52	0·7766
17	1·1259	43	1·3945	69	1·8313	27	0·8957	53	0·7725
18	1·1343	44	1·4074	70	1·8537	28	0·8902	54	0·7684
19	1·1428	45	1·4206	71	1·8765	29	0·8848	55	0·7643
20	1·1515	46	1·4339	72	1·9000	30	0·8795	56	0·7604
21	1·1603	47	1·4476	73	1·9241	31	0·8742	57	0·7656
22	1·1692	48	1·4615	74	1·9187	32	0·8690	58	0·7526
23	1·1783	49	1·4758	75	1·9740	33	0·8639	59	0·7487
24	1·1875	50	1·4902	76	2·0000	34	0·8588	60	0·7449
25	1·1968	51	1·4951			35	0·8538	61	0·7411

ARGILLACEOUS EARTH. The earth of clay, called in chemistry alumina, because it is obtained in greatest purity from alum.

ARGOL. Crude *tartar;* which see.

ARMS. Weapons of war. See FIRE-ARMS for an account of this manufacture.

ARRACK. A kind of intoxicating beverage made in India, by distilling the fermented juice of the cocoa-nut, the palmyra tree, and rice in the husk.

ARROW ROOT. The root of the *maranta arundinacea,* a plant which grows in the West Indies, furnishes, by pounding in mortars and elutriation through sieves, a peculiar species of starch, commonly, but improperly called arrow root. It is reckoned more nourishing than the starch of wheat or potatoes, and is generally also freer from peculiar taste or flavor. The fresh root consists, according to Benzon, of 0·07 of volatile oil; 26 of starch (23 of which are obtained in the form of powder, while the other 3 must be extracted from the parenchyma in a paste by boiling water); 1·58 of vegetable albumen; 0·6 of a gummy extract; 0·25 of chloride of calcium; 6 of insoluble fibrine; and 65·6 of water.

The import duty upon arrow root from our own colonies is 1s. per cwt.; from foreign parts 2d. per lib. In 1835, 987,966 lbs. were imported, of which only 6267 were exported; leaving 895,406 for home consumption. The total revenue derived that year from arrow root, was 518l. See STARCH.

ARSENIC. This metal occurs native in the state of oxyde, and also combined with sulphur under the improper name of *yellow* and *red arsenic,* or orpiment and realgar. Arsenic is associated with a great many metallic ores; but it is chiefly extracted from those of cobalt, by roasting, in which case the white oxyde of arsenic, or, more correctly, the arsenious acid is obtained. This acid is introduced occasionally in small quantities

into the materials of flint glass, either before their fusion, or in the melting pot. It serves
to peroxydize the iron oxide in the sand, and thereby to purify the body of the glass:
but an excess of it makes the glass milky.

Scheele's green is a combination of this arsenious acid with oxyde of copper, or an
arsenite of copper, and is described under this metal.

Arseniate of potash is prepared, in the small way, by exposing to a moderate heat in a
crucible, a mixture of equal parts of white arsenic and nitre in powder. After fusion,
the crucible is to be cooled; the contents being dissolved in hot water, and the solution
filtered, will afford regular crystals on cooling. According to M. Berzelius, they are
composed of arsenic acid, 63·87; potash, 26·16; and water, 9·97. It is an acidulous
salt, and is hence usually called the binarseniate, to denote that its composition is 2
atoms of arsenic acid, and 1 of potash. This article is prepared upon the great scale, in
Saxony, by melting nitre and arsenious acid together in a cylinder of cast-iron. A
neutral arseniate also is readily formed, by saturating the excess of acid in the above salt
with potash; it does not crystallize. The acid arseniate is occasionally used in calico
printing, for preventing certain points of the cotton cloth from taking on the mordant;
with which view it is mixed up with gum water and pipe-clay into a paste, which is ap-
plied to such places with a block.

The extraction of arsenic from the cobalt ores, is performed at Altenberg and Reichen-
stein, in Silesia, with an apparatus, excellently contrived to protect the health of the
smelters from the vapors of this most noxious metallic sublimate.

Figs. 20 to 23 represent the arsenical furnaces at Altenberg. *Fig.* 20 is a vertical
section of the poison tower; *fig.* 21, a longitudinal section of the subliming furnace A,
with the adjoining vault B, and the poison tower in part at *n*; *fig.* 22, the transverse
section of the furnace A, of *fig.* 21; *fig.* 23, ground plan of the furnace A, where the
left half shows the part above, and the right the part below the muffle or oblong
retort; B' is the upper view, B'' the ground plan of the vault B, of *fig.* 21; *m, n,* the
base of the poison tower. In the several figures the same letters denote the same objects;
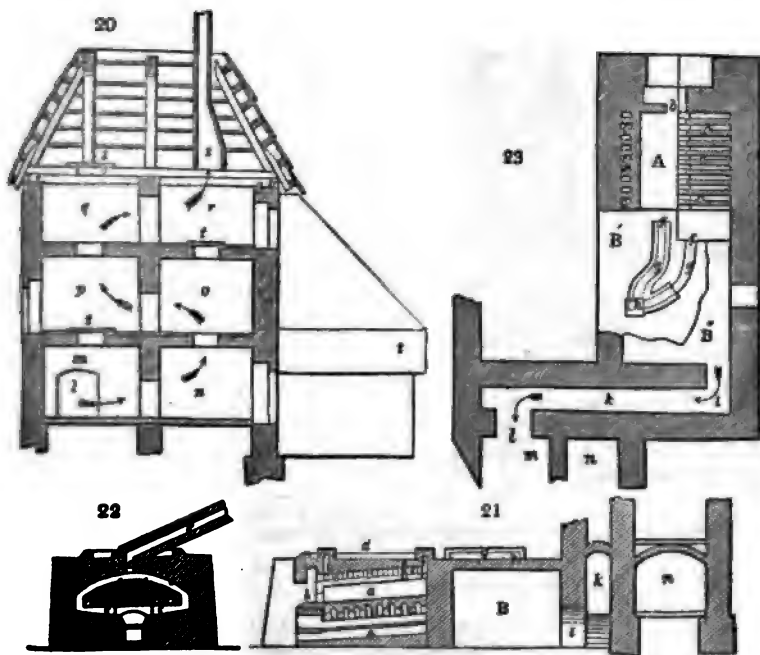
a is the muffle; *b* is its mouth for turning over the arsenical schlich, or ground ore;
c c c, fire draughts or flues; *d,* an aperture for charging the muffle with fresh schlich;
e, the smoke chimney; *f,* two channels or flues for the ascent of the arsenious fumes,
which proceed to other two flues *g,* and then terminate both in *h,* which conducts the
fumes into the vault B. They issue by the door *i,* into the conduit *k,* thence by *l* into the
spaces *m, n, o, p, q, r,* of the tower. The incondensable gases escape by the chimney, *s.*

The cover *l*, is removed after completion of the process, in order to push down the precipitate into the lower compartments.

The arsenious schlichs, to the amount of 9 or 10 cwt. for one operation (1 *roast-post*, or roasting round), are spread 2 or 3 inches thick upon the bottom of the muffle, heated with a brisk fire to redness, then with a gentler heat, in order to oxydize completely, before subliming, the arsenical ore. With this view the air must have free entrance, and the front aperture of the muffle must be left quite open. After 11 or 12 hours, the calcined materials are raked out by the mouth of the muffle, and fresh ones are introduced by the openings indicated above, which are closed during the sublimation.

The arsenious acid found in these passages is not marketable till it be re-sublimed in large iron pots, surmounted with a series of sheet iron drums or cast-iron cylinders, upon the sides of which the arsenic is condensed in its compact glassy form. The top cylinder is furnished with a pipe, which terminates in a condensing chamber.

Figs. 24, 25, represent the arsenic refining furnaces at Reichenstein. *Fig.* 24 shows
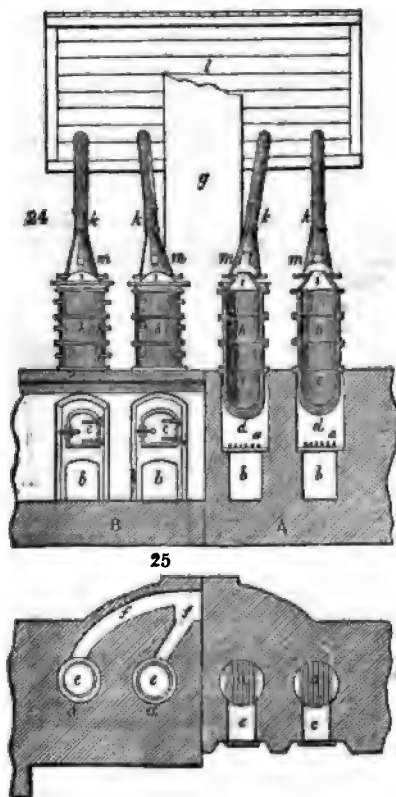
at A, a vertical section of the furnace. the kettle, and the surmounting drums or cylinders; over B it is seen in elevation; *fig.* 25 is a ground plan of the four fireplaces. *a* is the grate; *b*, the ash-pit; *c*, the openings for firing; *d*, the fire-place; *e*, iron pots or kettles which are charged with the arsenious powder; *f*, the fire-flues proceeding to the common chimney *g*; *h*, iron cylinders; *i*, caps; *k*, pipes leading to the poison vent *l*; *m*, openings in the pipes for introducing the probing wires.

The conduct of the process is as follows:—The pot is filled nearly to its brim with 3½ cwt. of the arsenic meal, the cylinders are fitted on by means of their handles, and luted together with a mixture of loam, blood, and hair; then is applied first a gentle, and after half an hour, a strong fire, whereby the arsenic is raised partly in the form of a white dust, and partly in crystals; which, by the continuance of the heat, fuse together into a homogeneous mass. If the fire be too feeble, only a sublimate is obtained; but, if too violent, much of the arsenic is volatilized into the pipes. The workmen judge by the heat of the cylinders whether the operation be going on well or not. After 12 hours the furnace is allowed to cool, provided the probe wires show that the sublimation is over. The cylinders are then lifted off, and the arsenious glass is detached from their inner surface. According to the quality of the poison flour, it yields from ⅔ to ⅓ of its weight of the glass or enamel. Should any dark particles of metallic arsenic be intermixed with the glass, a fresh sublimation must be had recourse to.

The following is the product in cwts. of arsenious acid, at Altenberg and Reichenstein, in Silesia, in the years

	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.
White arsenic in a glassy state - - - -	2632	1703	2686	1900	2070	2961	3337	2730
Sublimed arsenic in powder - - - -	-	27	33	31	30	44	69	38
Yellow arsenical glass -	112	11	58	-	86	313	60	219
Red arsenical glass -	3	-	-	-	28			

ARTESIAN WELLS. Under this name is designated a cylindrical perforation, bored vertically down through one or more of the geological strata of the earth, till it passes into a porous gravel bed containing water, placed under such incumbent pressure as to make it mount up through the perforation, either to the surface or to a height convenient for the operation of a pump. In the first case, these wells are called spouting or overflowing. This property is not directly proportional to the depth, as might at first sight be supposed, but to the subjacent pressure upon the water. We do not know exactly the period at which the borer or sound was applied to the investigation of subterranean fountains, but we believe the first overflowing wells were made in the ancient French province of Artois, whence the name of Artesian. These wells, of such importance to agriculture and manufactures, and which cost nothing to keep them in condition, have been in use, undoubtedly, for several centuries in the northern departments of France, and the north of Italy; but it is not more than 50 or 60 years since they became known in England and Germany. There are now a great many such wells in London and its neighborhood, perforated through the immensely thick bed of the London clay, and even through some portions of the subjacent chalk. The boring of such wells has given much insight into the geological structure of many districts.

The formation of Artesian wells depends on two things, essentially distinct from each other: 1. On an acquaintance with the physical constitution, or nature, of the mineral structure of each particular country; and, 2. On the skilful direction of the processes by which we can reach the water level, and of those by which we can promote its ascent in the tube. We shall first treat of the best method of making the well, and then offer some general remarks on the other subjects.

The operations employed for penetrating the soil are entirely similar to those daily practised by the miner, in boring to find metallic veins; but the well excavator must resort to peculiar expedients to prevent the purer water, which comes from deep strata, mingling with the cruder waters of the alluvial beds near the surface of the ground, as also to prevent the small perforation getting eventually filled with rubbish.

The cause of overflowing wells has been ascribed to a variety of circumstances. But, as it is now generally admitted that the numerous springs which issue from the ground proceed from the infiltration of the waters progressively condensed in rain, dew, snow, &c. upon the surface of our globe, the theory of these interior streamlets becomes by no means intricate; being analogous to that of syphons and water jets, as expounded in the treatises on physics. The waters are diffused, after condensation, upon the surface of the soil, and percolate downwards, through the various pores and fissures of the geological strata, to be again united subterraneously in veins, rills, streamlets, or expanded films, of greater or less magnitude, or regularity. The beds traversed by numerous disjunctions will give occasion to numerous interior currents in all directions, which cannot be recovered, and brought to the day; but when the ground is composed of strata of sand, or gravel very permeable to water, separated by other strata nearly impervious to it, reservoirs are formed to our hand, from which an abundant supply of water may be spontaneously raised. In this case, as soon as the upper stratum is perforated, the waters may rise, in consequence of the hydrostatic pressure upon the lower strata, and even overflow the surface in a constant stream, provided the level from which they proceed be proportionally higher.

The sheets of water occur principally at the separation of two contiguous formations; and, if the succession of the geological strata be considered, this distribution of the water will be seen to be its necessary consequence. In fact, the lower beds are frequently composed of compact sandstone or limestone, and the upper beds of clay. In level countries, the formations being almost always in horizontal beds, the waters which feed the Artesian wells must come from districts somewhat remote, where the strata are more elevated, as towards the secondary and transition rocks. The copious streams condensed upon the sides of these colder lands may be therefore regarded as the proper reservoirs of our wells.

Fig. 26 represents the manner in which the condensed water of the heavens distributes itself under the surface of our globe. Here we have a geological section, showing the succession of the several formations, and the sheets or laminæ of water that exist at their boundaries, as well as in their sandy beds. The figure shows also very plainly that the height
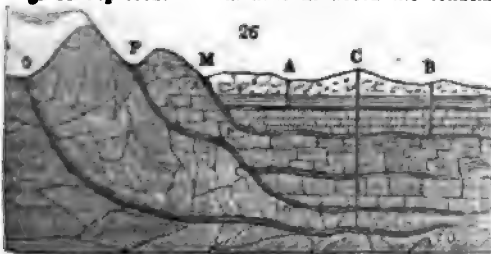
to which the water reascends in the bore of a well depends upon the height of the reservoir which supplies the sheet of water to which the well is perforated. Thus the well A, having gone down to the aqueous expanse *a a*, whose waters of supply are derived from the percolation M, will afford rising waters, which will come to the surface; while in the well B, supplied by the sheet P, the waters will spout above the surface, and in the well c they will remain short of it. The same figure shows that these wells often traverse sheets of water, which rise to different heights. Thus, in the well c there are five columns of ascending waters, which rise to heights proportional to the points whence they take their origin. Several of these will be spouting or overflowing, but some will remain beneath the surface.

The situation of the intended well being determined upon, a circular hole is generally dug in the ground, about 6 or 8 feet deep, and 5 or 6 feet wide. In the centre of this hole the boring is carried on by two workmen below, assisted by a laborer above, as shown in *fig.* 27.

The handle (*fig.* 28) having a female screw in the bottom of its iron shank, with a wooden bar or rail passing through the socket of the shank, and a ring at top, is the general agent to which all the boring implements are to be attached. A chisel
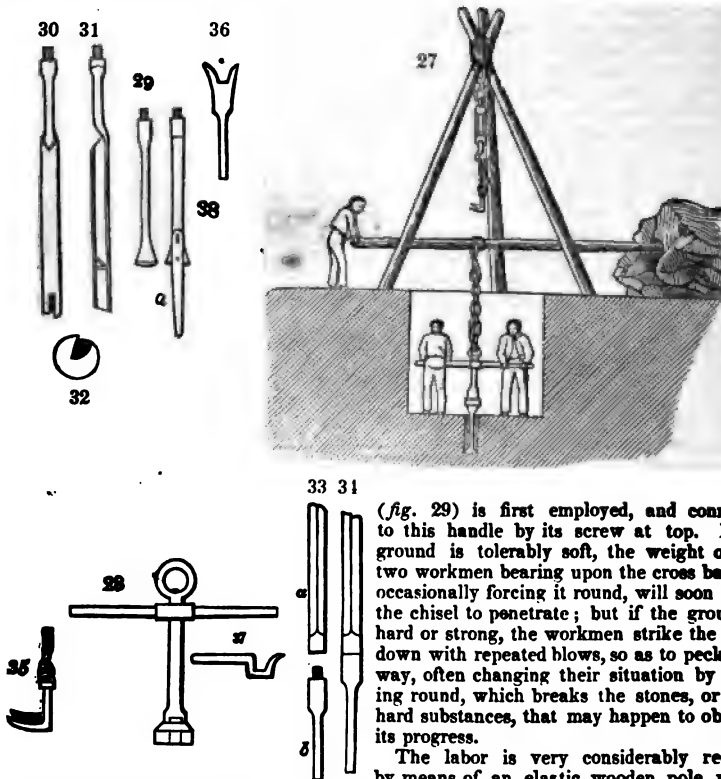
(*fig.* 29) is first employed, and connected to this handle by its screw at top. If the ground is tolerably soft, the weight of the two workmen bearing upon the cross bar, and occasionally forcing it round, will soon cause the chisel to penetrate; but if the ground is hard or strong, the workmen strike the chisel down with repeated blows, so as to peck their way, often changing their situation by walking round, which breaks the stones, or other hard substances, that may happen to obstruct its progress.

The labor is very considerably reduced by means of an elastic wooden pole, placed horizontally over the well, from which a chain is brought down, and attached to the ring of the handle. This pole is usually made fast at one end, as a fulcrum, by being set into a heap of heavy loose stones; at the other end the laborer above gives it a slight up and down vibrating motion, corresponding to the beating motion of the workmen below, by which means the elasticity of the pole in rising lifts the handle and pecker, and thereby very considerably diminishes the labor of the workmen. See *fig.* 27.

When the hole has been thus opened by a chisel, as far as its strength would permit, the chisel is withdrawn, and a sort of cylindrical auger (*fig.* 30) attached to the handle (*fig.* 28), for the purpose of drawing up the dirt or broken stones which have been disturbed by the chisel. A section of this auger is shown in *fig.* 31, by which the internal valve will be seen. The auger being introduced into the hole, and turned round by the workman, the dirt or broken stones will pass through the aperture at bottom (shown at

fig. 32), and fill the cylinder, which is then drawn up, and discharged at the top of the auger, the valve preventing its escape at bottom.

In order to penetrate deeper into the ground, an iron rod, as *a, fig.* 33, is now to be attached to the chisel, *fig.* 29, by screwing on to its upper end, and the rod is also fastened to the handle, *fig.* 28, by screwing into its socket. The chisel having thus become lengthened by the addition of the rod, it is again introduced into the hole; and the operation of pecking or forcing it down, is carried on by the workmen as before. When the ground has been thus perforated, as far as the chisel and its rod will reach, they must be withdrawn, in order again to introduce the auger, *fig.* 30, to collect and bring up the rubbish; which is done by attaching it to the iron rod, in place of the chisel. Thus, as the hole becomes deepened, other lengths of iron rods are added, by connecting them together, as *a b* are in *fig.* 34. The necessity of frequently withdrawing the rods from the holes, in order to collect the mud, stones, or rubbish, and the great friction produced by the rubbing of the tools against its sides, as well as the lengths of rods augmenting in the progress of the operation, sometimes to the extent of several hundred feet, render it extremely inconvenient, if not impossible, to raise them by hand. A tripedal standard is therefore generally constructed by three scaffolding poles tied together, over the hole, as shown *fig.* 27, from the centre of which a wheel and axle, or a pair of pully blocks is suspended, for the purpose of hauling up the rods, and from which hangs the fork, *fig.* 35. This fork is to be brought down under the shoulder, near the top of each rod, and made fast to it by passing a pin through two little holes in the claws. The rods are thus drawn up, about seven feet at a time, which is the usual distance between each joint, and at every haul a fork, *fig.* 36, is laid horizontally over the hole, with the shoulders of the lower rod resting between its claws, by which means the rods are prevented from sinking down into the hole again, while the upper length is unscrewed and removed. In attaching and detaching these lengths of rod, a wrench, *fig.* 37, is employed, by which they are turned round, and the screws forced up to their firm bearing.

The boring is sometimes performed for the first sixty or a hundred feet, by a chisel of 2½ inches wide, and cleared out by a gouge of 2½ diameter, and then the hole is widened by a tool, such as is shown at *fig.* 38. This is merely a chisel, as *fig.* 29, four inches wide, but with a guide, *a*, put on at its lower part, for the purpose of keeping it in a perpendicular direction; the lower part is not intended to peck, put to pass down the hole previously made, while the sides of the chisel operate in enlarging the hole to four inches. The process, however, is generally performed at one operation, by a chisel of four inches wide, as *fig.* 29, and a gouge of three inches and three quarters, as *fig.* 30.

It is obvious that placing and displacing the lengths of rod, which is done every time that the auger is required to be introduced or withdrawn, must, of itself, be extremely troublesome, independent of the labor of boring, but yet the operation proceeds, when so unpropitious circumstances attend it, with a facility almost incredible. Sometimes, however, rocks intercept the way, which require great labor to penetrate; but this is always effected by pecking, which slowly pulverizes the stone. The most unpleasant circumstance attendant upon this business is the occasional breaking of a rod into the hole, which sometimes creates a delay of many days, and an incalculable labor in drawing up the lower portion.

When the water is obtained in such quantities and of such quality as may be required, the hole is dressed or finished by passing down it a diamond chisel, funnel mouthed, with a triangular bit in its centre; this makes the sides smooth previous to putting in the pipe. This chisel is attached to rods, and to the handle, as before described; and, in its descent, the workmen continually walk round, by which the hole is made smooth and cylindrical. In the progress of the boring, frequent veins of water are passed through; but, as these are small streams, and perhaps impregnated with mineral substances, the operation is carried on until an aperture is made into a main spring, which will flow up to the surface of the earth. This must, of course, depend upon the level of its source, which, if in a neighboring hill, will frequently cause the water to rise up, and produce a continued fountain. But if the altitude of the distant spring happens to be below the level of the surface of the ground where the boring is effected, it sometimes happens that a well of considerable capacity is obliged to be dug down to that level, in order to form a reservoir, into which the water may flow, and whence it must be raised by a pump; while, in the former instance, a perpetual fountain may be obtained. Hence, it will always be a matter of doubt, in level countries, whether water can be procured which would flow near to or over the surface; if this cannot be effected, the process of boring will be of little or no advantage, except as an experiment to ascertain the fact.

In order to keep the strata pure and uncontaminated with mineral springs, the hole is cased, for a considerable depth, with a metallic pipe, about a quarter of an inch

smaller than the bore. This is generally made of tin (though sometimes of copper or lead) in convenient lengths; and, as each length is let down, it is held by a shoulder resting in a fork, while another length is soldered to it; by which means a continuous pipe is carried through the bore, as far as may be found necessary, to exclude land springs, and to prevent loose earth or sand from falling in, and choking the aperture.

Mr. John Good, of Tottenham, who had been extensively employed in boring the earth for water, obtained a patent, in Aug. 1823, for certain improved implements contrived by him to facilitate his useful labors; a description of which cannot fail to be interesting.

The figures annexed exhibit these ingenious tools; fig. 39 is an auger, to be connected

42 41 40 39 by the screw-head to the length of rods by which the boring is carried on. This auger is for boring in soft clay or sand; it is cylindrical, and has a slit or opening from end to end, and a bit, or cutting-piece at bottom. When the earth is loose or wet, an auger of the same form is to be employed, but the slit or opening reduced in width, or even without a slit or opening. A similar auger is used for cutting through chalk; but the point or bit at bottom should then project lower, and, for that purpose, some of these cylindrical augers are made with moveable bits, to be attached by screws, which is extremely desirable in grinding them to cutting edges. Fig. 40 is a hollow conical auger, for boring loose sandy soils; it has a spiral cutting edge coiled round it, which, as it turns, causes the loose soil to ascend up the inclined plane, and deposite itself in the hollow within. Fig. 41 is a hollow cylinder or tube, shown in section, with a foot-valve, and a bucket to be raised by a rod and cord attached at the top; this is a pumping tool, for the purpose of getting up water and sand that would not rise by the auger. When this cylinder is lowered to the bottom of the bore, the bucket is lifted up by the rod and cord, and descends again by its own gravity, having a valve in the bucket, opening upwards, like other lift pumps; which, at every stroke, raises quantity of water and sand in the cylinder equal to the stroke; the ascent and descent the bucket being limited by a guide-piece at the top of the cylinder, and two small knobs upon the rod which stop against the cross-guide. Fig. 42 is a tool for getting up broken rods. It consists of a small cylindrical piece at bottom, which the broken rod slips through when it is lowered, and a small catch with a knife-edge, acted upon by a back-spring. In rising, the tool takes hold of the broken rod, and thereby enables the workman on top to draw it up. Another tool for the same purpose, is shown at fig. 43, which is like a pair of tongs; it is intended to be slidden down the bore, and for the broken rod to pass between the two catches, which, pressed by back-springs, will, when drawn up, take firm hold of the broken rod.

Fig. 44 is a tool for widening the hole, to be connected, like all the others, to the end

49 43 44 45
52 56 50   47

51

53
55   54

of the length of rods passed down the bore; this tool has two cutting-pieces extending the sides at bottom, by which as the tool is turned round the bore, the earth is peeled away. Fig. 45 is a chisel, punch, with a projecting piece to be used for penetrating through stone; this chisel by rising and falling, made to peck the stone, and pulverize it; the small middle part breaking it away first, and afterwards the broad part coming into action. Fig. 46 is another chisel or punching tool, twisted on its cutting edge, which breaks away

a greater portion of the stone as it beats against it.

The manner of forcing down lengths of cast-iron pipe, after the bore is formed, is shown at fig. 47; the pipe is seen below in the socket, at the end of which a block is inserted; and from this block a rod extends upwards, upon which a weight at top slides. To this weight cords are shown to be attached, reaching to the top of the bore, where the workmen alternately raise the weight and let it fall, which, by striking upon the block in its middle, beats down the pipe by a succession of strokes; and when a length of pipe has, by these means, been forced down, another length is introduced into
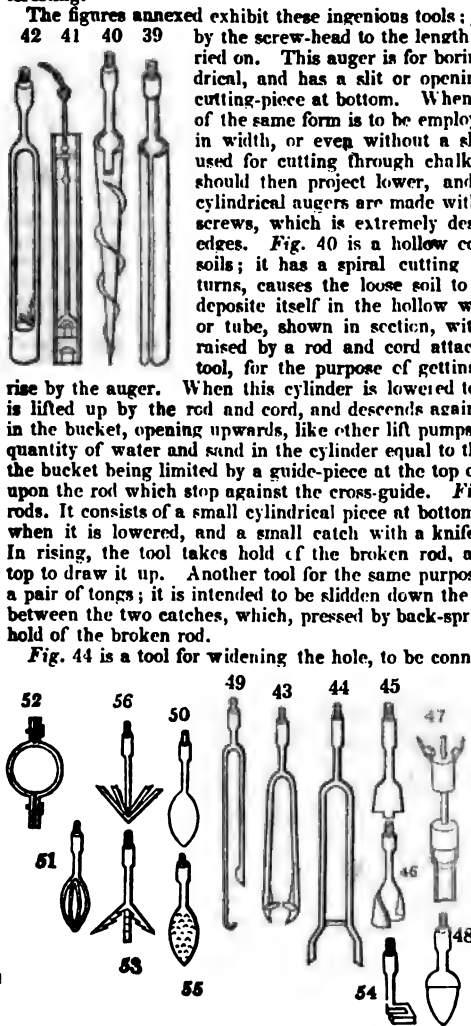
the socket of the former. Another tool for the same purpose is shown at *fig.* 48, which is formed like an acorn; the raised part of the acorn strikes against the edge of the pipe, and by that means, it is forced down the bore. When it happens that an auger breaks in the hole, a tool similar to that shown at *fig.* 49 is introduced; on one side of this tool a curved piece is attached, for the purpose of a guide, to conduct it past the cylindrical auger; and at the end of the other side is a hook, which, taking hold of the bottom edge of the auger, enables it to be drawn up.

Wrought iron, copper, tin, and lead pipes, are occasionally used for lining the bore; and as these are subject to bends and bruises, it is necessary to introduce tools for the purpose of straightening their sides. One of these tools is shown at *fig.* 50, which is a bow, and is to be passed down the inside of the pipe, in order to press out any dents. Another tool, for the same purpose, is shown at *fig.* 51, which is a double bow, and may be turned round in the pipe for the purpose of straightening it all the way down; at *fig.* 52, is a pair of clams, for turning the pipe round in the hole while driving.

When loose stones lie at the bottom of the hole, which are too large to be brought up by the cylindrical auger, and cannot be conveniently broken, then it is proposed to introduce a triangular claw, as *fig.* 53, the internal notches of which take hold of the stone, and as the tool rises, bring it up. For raising broken rods, a tool like *fig.* 54 is sometimes employed, which has an angular claw that slips under the shoulder of the rod, and holds it fast while drawing up.

In raising pipes it is necessary to introduce a tool into the inside of the pipe, by which it will be held fast. *Fig.* 55 is a pine-apple-tool for this purpose; its surface is cut like a rasp, which passes easily down into the pipe, but catches as it is drawn up; and by that means brings the pipe with it. *Fig.* 56 is a spear for the same purpose, which easily enters the pipe by springing; at the ends of its prongs there are forks which stick into the metal as it is drawn up, and thereby raise it.

These are the new implements, for which the patent was granted. In the process of boring, there does not appear to be anything new proposed; but that these several tools are to be employed for boring, packing. and otherwise penetrating, raising the earth, and extracting broken or injured tools. There are also suggestions for employing long buckets, with valves opening upward in their bottoms, for the purpose of drawing water from these wells when the water will not flow over the surface; also lift pumps, with a succession of buckets for the same purpose. But as these suggestions possess little if any novelty, it cannot be intended to claim them as parts of the patent.

ASPHALTUM. Native bitumen, so called from the lake Asphaltites.

ASSAY and ASSAYING. (*Coupellation*, Fr.; *Abtreiben auf der capelle*, Germ.) This is the process by which the quality of gold and silver bullion, coin, plate, or trinkets is ascertained with precision, or by which the quantity of either or both these precious metals is determined in any given alloy. It is, therefore, a case of chemical analysis, in which peculiar methods are employed to attain the object in view with accuracy and despatch. Assaying has been also extended, of late years, to determine the quantity of palladium and platina in certain bullion and gold dust brought from Brazil.

The art of assaying gold and silver *by the cupel*, is founded upon the feeble affinity which these metals have for oxygen, in comparison with copper, tin, and the other cheaper metals; and on the tendency which the latter metals have to oxydize rapidly in contact with lead at a high temperature, and sink with it into any porous earthy vessel in a thin glassy or vitriform state. The porous vessel may be made either of wood-ashes, freed from their soluble matter by washing with water; or, preferably, of burned bones reduced to a fine powder.

The lead added to the silver or gold to be assayed, serves chiefly to dissolve the oxydised copper, whence it appears that the quantity of lead requisite for silver assays, ought to be directly proportional to the quantity which the silver and copper would separately require. It has been found by experiment, that 16 parts of lead are quite sufficient to pass 1 of copper through the cupel; and that $\frac{3}{10}$ of lead presents the most suitable proportion for passing one of silver. From these principles, however, if we should always regard the dose of lead to be employed for any alloy as being equal to $N \times C + \frac{3}{10} \times S$ we should certainly commit an error. The phenomena of cupellation is of a more complex nature. Long practice and delicate trials alone can guide to the proper quantity of lead to be employed for every various state of the alloy. The following Table contains the results of M. D'Arcet's elaborate experiments upon this subject:—

Alloy.		Lead for 1 of Alloy.	Ratio of the Copper to the Lead.
Silver.	Copper.		
1000	0	1¾	0
950	50	3	1 : 60
900	100	7	1 : 70
800	200	10	1 : 50
700	300	12	1 : 40
600	400	14	1 : 35
500	500	16 or 17	1 : 32
400	600	16 — 17	1 : 26·7
300	700	16 — 17	1 : 22·9
200	800	16 — 17	1 : 20
100	900	16 — 17	1 : 17·8
0	1000	16 — 17	1 : 16

Bismuth may be used as a substitute for lead in cupellation; two parts of it being nearly equivalent to three of lead. But its higher prices will prevent its general introduction among assay masters.

We begin this assay process by weighing, in a delicate balance, a certain weight of the metallic alloy; a gramme (=15·444 gr.) is usually taken in France, and 12 grains in this country. This weight is wrapped up in a slip of lead foil or paper, should it consist of several fragments. This small parcel, thus enveloped, is then laid in a watch glass or a capsule of copper, and there is added to it the proportion of lead suited to the quality of alloy to be assayed; there being less lead, the finer the silver is presumed to be. Those who are much in the habit of cupellation can make good guesses in this way; though it is still guess work, and often leads to considerable error, for if too much lead be used for the proportion of baser metal present, a portion of the silver is wasted; but if too little, then the whole of the copper, &c. is not carried off, and the button of fine silver remains more or less impure. The most expert and experienced assayer by the cupel, produces merely a series of approximate conjectural results which fall short of chemical demonstration and certainty in every instance. The lead must be in all cases, entirely free from silver, being such as has been revived from pure litharge; otherwise errors of the most serious kind would be occasioned in the assays.

The best cupels weigh 12½ grammes, or 193 grains. The cupels allow the fused oxydes to flow through them as through a fine sieve, but are impermeable to the particles of metals; and thus the former pass readily down into their substance while the latter remain upon their surface; a phenomenon owing to the circumstance of the glassy oxydes moistening, as it were, the bone-ash powder, whereas the metals contract no adherence with it. Hence also the liquid metals preserve a hemispherical shape in the cupels, as quicksilver does in a cup of glass, while the fused oxyde spreads over, and penetrates their substance like water. A cupel may be regarded, in some measure, as a filter permeable only to certain liquids.

If we put into a cupel, therefore, two metals, of which the one is unalterable in air, the other susceptible of oxydizement, and of producing a very fusible oxyde, it is obvious that, by exposing both to a proper degree of heat, we shall succeed in separating them. We should also succeed, though the oxyde were infusible, by placing it in contact with another one, which may render it fusible. In both cases, however, the metal from which we wish to part the oxydes must not be volatile should also melt, and form a button at the heat of cupellation; for otherwise it would continue disseminated, tached to the portion of oxyde spread over the cupel, incapable of being collected.

58

The furnace and implements used for assaying in Royal Mint and the Goldsmiths' Hall, in the city of London, are the following :—

A A A A, fig. 58, is a front elevation of an assay furnace a a, a view of one of the two iron rollers on which the nace rests, and by means of which it is moved forward backward; b, the ash-pit; c c are the ash-pit dampers which are moved in a horizontal direction towards other for regulating the draught of the furnace; d, the door, or opening, by which the cupels and assays are introduced into the muffle; e, a moveable funnel or chimney by which the draught of the furnace is increased.
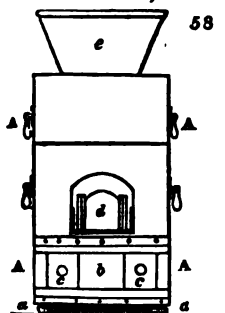
B B B B, *fig.* 59, is a perpendicular section of *fig.* 58; *a a*, end view of the rollers; *b* the ash-pit; *c* one of the ash-pit dampers; *d* the grate, over which is the plate upon which the muffle rests, and which is covered with loam nearly one inch thick; *f* the muffle in section representing the situation of the cupels; *g* the mouth-plate, and upon it are laid pieces of charcoal, which during the process are ignited, and heat the air that is allowed to pass over the cupels, as will be more fully explained in the sequel; *h* the interior of the furnace, exhibiting the fuel.
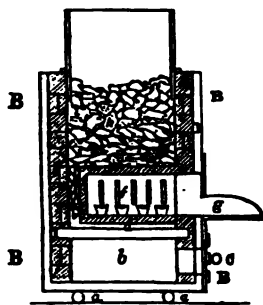
The total height of the furnace is 2 feet 6½ inches; from the bottom to the grate, 6 inches; the grate, muffle, plate, and bed of loam, with which it is covered, 3 inches; from the upper surface of the grate to the commencement of the funnel *e*, *fig.* 58, 21½ inches; the funnel *e*, 6 inches. The square of the furnace which receives the muffle and fuel is 11¾ inches by 15 inches. The external sides of the furnace are made of plates of wrought iron, and are lined with a 2-inch fire-brick.

c c c c, *fig.* 60, is a horizontal section of the furnace over the grate, showing the width of the mouth-piece, or plate of wrought iron, which is 6 inches, and the opening which receives the muffle-plate.
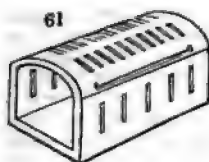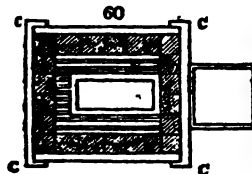
Fig. 61, represents the muffle or pot, which is 12 inches long, 6 inches broad inside; in the clear 6¾: in height 4½ inside measure, and nearly 5¼ in the clear.

Fig. 62, the muffle-plate, which is of the same size as the bottom of the muffle.

Fig. 63, is a representation of the sliding-door of the mouth-plate, as shown at *d*, in *fig.* 58.
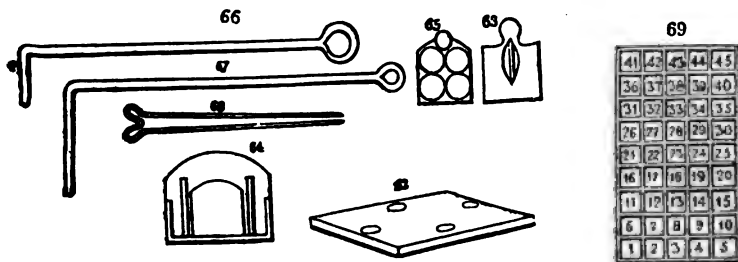
Fig. 64, a front view of the mouth-plate or piece, *d*, *fig.* 58.

Fig. 65, a representation of the mode of making, or shutting up with pieces of charcoal, the mouth of the furnace.

Fig. 66, the teaser for cleaning the grate.

Fig. 67, a larger teaser, which is introduced at the top of the furnace, for keeping a complete supply of charcoal around the muffle.

Fig. 68, the tongs used for charging the assays into the cups.

Fig. 69, represents a board of wood used as a register, and is divided into 45 equal compartments, upon which the assays are placed previously to their being introduced into the furnace. When the operation is performed, the cupels are placed in the furnace in situations corresponding to these assays on the board. By these means all confusion is avoided, and without this regularity it would be impossible to preserve the accuracy which the delicate operations of the assayer require.

I shall now proceed to a description of a small assay furnace, invented by Messrs. Anfrye and d'Arcet, of Paris. They term it, *Le Petit Fourneau à Coupelle. Fig.* 70 represents this furnace, and it is composed of a chimney or pipe of wrought iron *a*, and of the furnace B. It is 17¼ inches high, and 7¼ inches wide. The furnace is formed of three pieces; of a dome A; the body of the furnace B; and the ash-pit c, which is

used as the base of the furnace, *figs.* 70 and 71. The principal piece, or body of the furnace, **B**, has the form of a hollow tower, or of a hollow cylinder, flattened equally at the two opposite sides parallel to the axis, in such a manner that the horizontal section is elliptical. The foot which supports it is a hollow truncated cone flattened in like manner upon the two opposite sides, and having consequently for its basis two ellipses
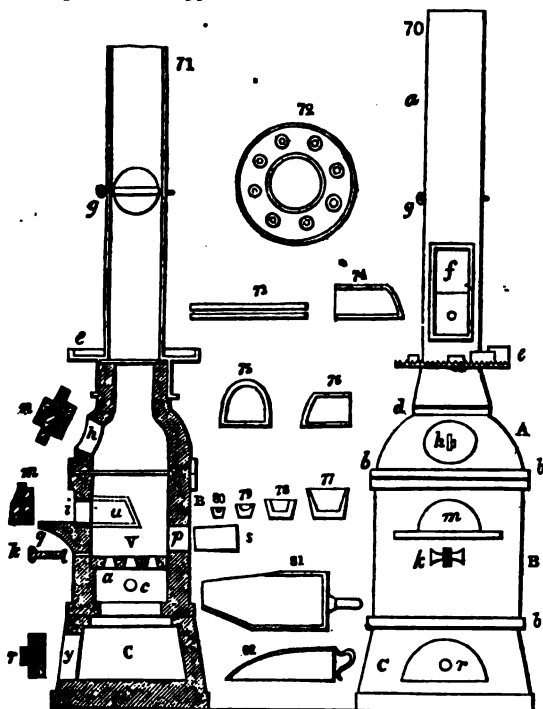
of different diameters ; the smallest ought to be equal to that of the furnace, so that the bottom of the latter may exactly fit it. The dome, which forms an arch above the furnace, has also its base elliptical, while that of the superior orifice by which the smoke goes out preserves the cylindrical form. The tube of wrought iron is 18 inches long and 2½ inches diameter, having one of its ends a little enlarged, and slightly conical, that it may be exactly fitted or jointed upon the upper part of the furnace dome *fig.* 70. At the union of the conical and cylindrical parts of the tube, there is placed a small gallery of iron, *e, fig.* 70, 71. See also a plan of it, *fig.* 72. This gallery is both ingenious and useful.

Upon it are placed the cupels, which are thus annealed during the ordinary work of the furnace, that they may be introduced into the muffle, when it is brought into its proper degree of heat. A little above this gallery is a door *f*, by which, if thought proper, the charcoal could be introduced into the furnace; above that there is placed at *g* a throttle valve, which is used for regulating the draught of the furnace at pleasure. Messrs. Anfrye and d'Arcet say, that, to give the furnace the necessary degree of heat so as to work the assays of gold, the tube must be about 18 inches above the gallery, for annealing or heating the cupels. The circular opening *h*, in the dome, *fig.* 70, and as seen in the section, *fig.* 71, is used to introduce the charcoal into the furnace : it is also used to inspect the interior of the furnace, and to arrange the charcoal round the muffle. This opening is kept shut during the working of the furnace, with the mouth-piece, of which the face is seen at *n, fig.* 71.

The section of the furnace. *fig.* 71, presents several openings, the principal of which is that of the muffle ; it is placed at *i*; it is shut with the semicircular door *m, fig.* 70, and seen in the section *m, fig.* 71. In front of this opening, is the table or shelf, upon which the door of the muffle is made to advance or recede; the letter *q, fig.* 71, shows the face, side, and cross section of the shelf, which makes part of the furnace. Immediately under the shelf, is a horizontal slit, *l*, which is pierced at the level of the upper part of the grate, and used for the introduction of a slender rod of iron, that the grate may be easily kept clean. This opening is shut at pleasure, by the wedge represented at *k, figs.* 70, and 71.

Upon the back of the furnace is a horizontal slit *p, fig.* 71, which supports the fire-brick, *s*, and upon which the end of the muffle, if necessary, may rest ; *u, fig.* 71, is the opening in the furnace where the muffle is placed.

The plan of the grate of the furnace is an ellipse : *fig.* 73, is a horizontal view of it. The dimensions of that ellipsis determine the general form of the furnace, and thickness of the grate. To give strength and solidity to the grate, it is encircled by a bar or hoop of

area. There is a groove in which the hoop of iron is fixed. The holes of the grate are truncated cones, having the greater base below, that the ashes may more easily fall into the ash-pit. The letter *v*, *fig.* 71, shows the form of these holes. The grate is supported by a small bank or shelf, making part of the furnace, as seen at *a*, *fig.* 71.

The ash-pit, c, has an opening *y* in front, *fig.* 71; and is shut when necessary by the mouth-piece *r*, *figs.* 70 and 71.

To give strength and solidity to the furnace, it is bound with hoops of iron, at *b*, *b*, *b*, *b*, *fig.* 70.

Figs. 74, 75, 76, are views of the muffle.

Fig. 77 is a view of a crucible for annealing gold.

Figs. 78, 79, 80, are cupels of various sizes, to be used in the furnace. They are the same as those used by assayers in their ordinary furnaces.

Figs. 81 and 82 are views of the hand-shovels, used for filling the furnace with charcoal; they should be made of such size and form as to fit the opening *h*, in *figs.* 70 and 71.

The smaller pincers or tongs, by which the assays are charged into the cupels, and by which the latter are withdrawn from the furnace, as well as the teaser for cleaning the grate of the furnace, are similar to those used in the British Mint.

In the furnace of the Mint above described, the number of assays that can be made at one time is 45. The same number of cupels are put into the muffle. The furnace is then filled with charcoal to the top, and upon this are laid a few pieces already ignited. In the course of three hours, a little more or less, according to circumstances, the whole is ignited; during which period, the muffle, which is made of fire-clay, is gradually heated to redness, and is prevented from cracking; which a less regular or more sudden increase of temperature would not fail to do: the cupels, also, become properly annealed. All moisture being dispelled, they are in a fit state to receive the piece of silver or gold to be assayed.

The greater care that is exercised in this operation, the less liable is the assayer to accidents from the breaking of the muffle; which is both expensive and troublesome to fit properly into the furnace.

The cupels used in the assay process, are made of the ashes of burnt bones (phosphate of lime). In the Royal Mint, the cores of ox-horn are selected for this purpose; and the ashes produced are about four times the expense of the bone-ash, used in the process of cupellation upon a large scale. So much depends upon the accuracy of an assay of gold or silver, where a mass of 15lbs. troy in the first, and 60lbs troy in the second instance is determined by the analysis of a portion not exceeding 20 troy grains, that every precaution which the longest experience has suggested, is used to obtain an accurate result. Hence the attention paid to the selection of the most proper materials for making the cupels.

The cupels are formed in a circular mould made of cast steel, very nicely turned, by which means they are easily freed from the mould when struck. The bone-ash is used moistened with a quantity of water, sufficient to make the particles adhere firmly together. The circular mould is filled, and pressed level with its surface; after which, a pestle or rammer, having its end nicely turned, of a globular or convex shape, and of a size equal to the degree of concavity wished to be made in the cupel for the reception of the assay, is placed upon the ashes in the mould, and struck with a hammer until the cupel is properly formed. These cupels are allowed to dry in the air for some time before they are used. If the weather is fine, a fortnight will be sufficient.

An assay may prove defective for several reasons. Sometimes the button or bead sends forth crystalline vegetations on its surface with such force, as to make one suppose a portion of the silver may be thrown out of the cupel. When the surface of the bead is dull and flat, the assay is considered to have been too hot, and it indicates a loss of silver in fumes. When the tint of the bead is not uniform, when its inferior surface is bubbly, when yellow scales of oxyde of lead remain on the bottom of the cupel, and the bead adheres strongly to it, by these signs it is judged that the assay has been too cold, and that the silver retains some lead.

Lastly, the assay is thought to be good if the bead is of a round form, if its upper surface is brilliant, if its lower surface is granular and of a dead white, and if it separates readily from the cupel.

After the lead is put into the cupel, it gets immediately covered with a coat of oxyde, which resists the admission of the silver to be assayed into the melted metal; so that the alloy cannot form. When a bit of silver is laid on a lead bath in this predicament, we see it swim about for a long time without dissolving. In order to avoid this result, the silver is wrapped up in a bit of paper; and the carbureted hydrogen generated by its combustion reduces the film of the lead oxyde, gives the bath immediately a bright metallic lustre, and enables the two metals readily to combine.

As the heat rises, the oxyde of lead flows round about over the surface, till it is ab-

sorbed by the cupel. When the lead is wasted to a certain degree, a very thin film or it only remains on the silver, which causes the iridescent appearance, like the colors of soap-bubbles; a phenomenon, called by the old chemists, fulguration.

When the cupel cools in the progress of the assay, the oxygenation of the lead ceases; and, instead of a very liquid vitreous oxyde, an imperfectly melted oxyde is formed, which the cupel cannot absorb. To correct a cold assay, the temperature of the furnace ought to be raised, and pieces of paper ought to be put into the cupel, till the oxyde of lead which adheres to it be reduced. On keeping up the heat, the assay will resume its ordinary train.

Pure silver almost always vegetates. Some traces of copper destroy this property, which is obviously due to the oxygen which the silver can absorb while it is in fusion, and which is disengaged the moment it solidifies. An excess of lead, by removing all the copper at an early stage, tends to cause the vegetation.

The brightening is caused by the heat evolved, when the button passes from the liquid to the solid state. Many other substances present the same phenomenon.

In the above operation it is necessary to employ lead which is very pure, or at least free from silver. That kind is called *poor lead*.

It has been observed at all times, that the oxyde of lead carries off with it, into the cupel, a little silver in the state of an oxyde. This effect becomes less, or even disappears, when there is some copper remaining; and the more copper, the less chance there is of any silver being lost. The loss of silver increases, on the other hand, with the dose of lead. Hence the reason why it is so important to proportion the lead with a precision which, at first sight, would appear to be superfluous. Hence, also, the reason of the attempts which have, of late years, been made to change the whole system of silver assays, and to have recourse to a method exempt from the above causes of error.

M. d'Arcet, charged by the Commission of the Mint in Paris, to examine into the justice of the reclamations made by the French silversmiths against the public assays, ascertained that they were well founded; and that the results of cupellation gave for the alloys betwen 897 and 903 thousandths (the limits of their standard coin) an inferior standard, by from 4 to 5 thousandth parts, from the standard or title which should result from the absolute or actual alloy.

The mode of assay shows, in fact, that an ingot, experimentally composed of 900 thousandths of fine silver, and 100 thousandths of copper, appears, by cupellation, to be only, at the utmost, 896 or 897 thousandths; whereas fine silver, of 1000 thousandths, comes out nearly of its real standard. Consequently a director of the Mint, who should compound his alloy with fine silver, would be obliged to employ 903 or 904 thousandths, in order that, by the assay in the laboratory of the Mint, it should appear to have the standard of 900 thousandths. These 3 or 4 thousandths would be lost to him, since they would be disguised by the mode of assay, the definitive criterion of the quantity of silver, of which the government keeps count from the coiner of the money.

From the experiments subsequently made by M. d'Arcet, it appears that silver assays always suffer a loss of the precious metal, which varies, however, with the standard of the alloy. It is 1 thousandth for fine silver,

4·3 thousandths for silver of 900 thousandths,
4·9 — for — of 800 —
4·2 — for — of 500 —

and diminishes thereafter, progressively, till the alloy contains only 100 thousandths of silver, at which point the loss is only 0·4.

Assays requested by the Commission of the Paris Mint, from the assayers of the principal Royal Mints in Europe, to which the same alloys, synthetically compounded, were sent, afforded the results inscribed in the following table.

Names of the Assayers.	Cities where they reside.	Standards found for the Mathematical Alloys		
		950 mill.	900 mill.	800 mill.
F. de Castenhole, Mint Assayer	Vienna	946·20	898·40	795·10
A. R. Vervaëz, ditto	Madrid	944·40	893·70	789·20
D. M. Cabrera, Assayer in Spain	Ditto	944·40	893·70	788·60
Assayer	Amsterdam	947·00	895·00	795·00
Mr. Bingley, Assay Master	London	946·25	896·25	794·25
Mr. Johnson, Assayer	Ditto	933·33	883·50	783·33
Inspector of the Mint	Utrecht	945·00	896·50	799·00
Assayer of the Mint	Naples	945·00	891·00	787·00
Assayer of Trade	Ditto	945·00	891·00	787·00
Assayer of the Mint	Hamburgh	946·$\frac{1}{2}\frac{3}{2}$	897·$\frac{1}{2}\frac{1}{2}$	798·$\frac{1}{2}\frac{1}{2}$
Ditto	Altona	942·$\frac{1}{2}$	894·00	790

These results, as well as those in still greater numbers, obtained from the ablest Parisian assayers, upon identical alloys of silver and copper, prove that the mode of assay applied to them brings out the standard too low; and further, that the quantity of silver masked or disguised, is not uniform for these different eminent assay masters. An alloy, for example, at the standard of 900 thousandths is judged at

		M.
the Mint of Paris to have a standard of		895·6
At that of Vienna	—	898·4
— Madrid	—	893·7
— Naples	—	891·0

The fact thus so clearly made out of a loss in the standard of silver bullion and coin, merits the most serious attention; and it will appear astonishing, perhaps, that a thing recurring every day, should have remained for so long a time in the dark. In reality, however, the fact is not new; as the very numerous and well-made experiments of Tillet, from 1760 to 1763, which are related in the memoirs of the Academy of Sciences, show, in the silver assays, a loss still greater than that which was experienced lately in the laboratory of the Commission of the French Mint. But he thought that, as the error was common to the nations in general, it was not worth while or prudent to introduce any innovation.

A mode of assaying, to give, with certainty, the standard of silver bullion, should be entirely independent of the variable circumstances of temperature, and the unknown proportions of copper, so difficult to regulate by the mere judgment of the senses. The process by the humid way, recommended by me to the Royal Mint in 1829, and exhibited as to its principles before the Right Honorable John Herries, then Master, in 1830, has all the precision and certainty we could wish. It is founded on the well-known property which silver has, when dissolved in nitric acid, to be precipitated in a chloride of silver quite insoluble, by a solution of sea salt, or by muriatic acid; but, instead of determining the weight of the chloride of silver, which would be somewhat uncertain and rather tedious, on account of the difficulty of drying it, we take the quantity of the solution of sea salt which has been necessary for the precipitation of the silver. To put the process in execution, a liquor is prepared, composed of water and sea salt in such proportions that 1000 measures of this liquor may precipitate, completely, 12 grains of silver, perfectly pure, or of the standard 1000, previously dissolved in nitric acid. The liquor thus prepared, gives, immediately, the true standard of any alloy whatever, of silver and copper, by the weight of it which may be necessary to precipitate 12 grains of this alloy. If, for example, 905 measures have been required to precipitate the 12 grains of alloy, its standard would be 905 thousandths.

The process by the humid way is, so to speak, independent of the operator. The manipulations are so easy; and the term of the operation is very distinctly announced by the absence of any sensible nebulosities on the affusion of sea salt into the silver solution, while there remains in it ⅓ thousandth of metal. The process is not tedious, and in experienced hands it may rival the cupel in rapidity; it has the advantage over the cupel of being more within the reach of ordinary operators, and of not requiring a long apprenticeship. It is particularly useful to such assayers as have only a few assays to make daily, as it will cost them very little time and expense.

By agitating briskly during two minutes, or thereby, the liquid rendered milky by the precipitation of the chloride of silver, it may be sufficiently clarified to enable us to appreciate, after a few moments of repose, the disturbance that can be produced in it by the addition of 1000 of a grain of silver. Filtration is more efficacious than agitation, especially when it is employed afterwards; it may be sometimes used; but agitation, which is much more prompt, is generally sufficient. The presence of lead and copper, or any other metal, except mercury, has no perceptible influence on the quantity of sea salt necessary to precipitate the silver; that is to say, the same quantity of silver, pure or alloyed, requires for its precipitation a constant quantity of the solution of sea salt.

Supposing that we operate upon a gramme of pure silver, the solution of sea salt ought to be such that 100 centimetres cube may precipitate exactly the whole silver. The standard of an alloy is given by the number of thousandths of solution of sea salt necessary to precipitate the silver contained in a gramme of the alloy.
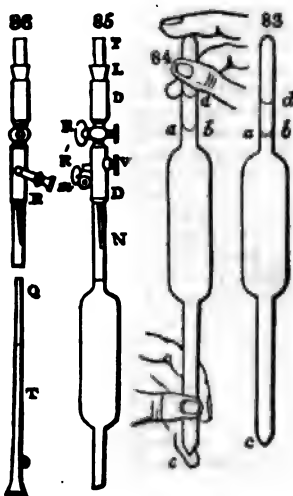
When any mercury is accidentally present, which is, however, a rare occurrence, it is made obvious by the precipitated chloride remaining white when exposed to daylight, whereas when there is no mercury present, it becomes speedily first gray and then purple. Silver so contaminated must be strongly ignited in fusion before being assayed, and its loss of weight noted. In this case, a cupel assay must be had recourse to.

Preparation of the Normal Solution of Sea Salt, when it is measured by Weight.—Supposing the sea salt pure as well as the water, we have only to take these two bodies in the proportion of 0·5427 k. of salt to 99·4573 k. of water, to have 100 k. of solution,

of which 100 grammes will precipitate exactly one gramme of silver. But instead of pure salt, which is to be procured with difficulty, and which besides may be altered readily by absorbing the humidity of the air, a concentrated solution of the sea salt of commerce is to be preferred, of which a large quantity may be prepared at a time, to be kept in reserve for use, as it is wanted. *Instruction de Gay Lussac.*

Preparation of the Normal Solution of Sea Salt, when measured by Volume.—The measure by weight has the advantage of being independent of temperature, of having the same degree of precision as the balance, and of standing in need of no correction. The measure by volume has not all these advantages; but, by giving it sufficient precision, it is more rapid, and is quite sufficient for the numerous daily assays of the mint. This normal solution is so made, that a volume equal to that of 100 grammes of water, or 100 centimetres cube, at a determinate temperature, may precipitate exactly one gramme of silver. The solution may be kept at a constant temperature, and in this case the assay stands in want of no correction; or if its temperature be variable, the assay must be corrected according to its influence. These two circumstances make no change in the principle of the process, but they are sufficiently important to occasion some modifications in the apparatus. Experience has decided the preference in favor of applying a correction to a variable temperature.

We readily obtain a volume of 100 cubic centimetres by means of a *pipette*, fig. 83, so gauged that when filled with water up to the mark *a, b*, and well dried at its point, it will run out, at a continuous efflux, 100 grammes of water at the temperature of 15 C. (59 Fah.). We say purposely at one efflux, because after the cessation of the jet, the pipette may still furnish two or three drops of liquid, which must not be counted or reckoned upon. The weight of the volume of the normal solution, taken in this manner with suitable precautions, will be uniform from one extreme to another, upon two centimetres and a half, at most, or to a quarter of a thousandth, and the difference from the mean will be obviously twice less, or one half. Let us indicate the most simple manner of taking a measure of the normal solution of sea salt.

After having immersed the beak *c* of the pipette in the solution, we apply suction by the mouth to the upper orifice, and thereby raise the liquid to *d*, above the circular line *a b*. We next apply neatly the forefinger of one hand to this orifice remove the pipette from the liquid, and seize it as represented in *fig.* 84. The mark *a b* being placed at the level of the eye, we make the surface of the solution become exactly a tangent to the plane *a b*. At the instant it becomes a tangent, we leave the beak *c* of the pipette open, by taking away the finger that had been applied to it, and without changing anything else in the position of the hands, we empty it into the bottle which should receive the solution, taking care to remove it whenever the efflux has run out.

If, after filling the pipette by suction, any one should find a difficulty in applying the forefinger fast enough to the upper orifice, without letting the liquid run down below the mark *a b*, he should remove the pipette from the solution with its top still closed with his tongue, then apply the middle finger of one of his hands to the lower orifice; after which he may withdraw his tongue, and apply the forefinger of the other hand to the orifice previously wiped. This mode of obtaining a measure of normal solution of sea salt is very simple, and requires no complex apparatus : but we shall indicate another manipulation still easier, and also more exact.

In this new process the pipette is filled from the top like a bottle, instead of being filled by suction, and it is moreover fixed. *Fig.* 85 represents the apparatus. D and D' are two sockets separated by a stop-cock R. The upper one, tapped interiorly, receives, by means of a cork stopper L, the tube T, which admits the solution of sea salt. The lower socket is cemented on to the *pipette*; it bears a small air-cock R', and a screw plug V, which regulates a minute opening intended to let the air enter very slowly into the pipette. Below the stop-cock R', a silver tube N, of narrow diameter, soldered to the socket, leads the solution into the *pipette*, by allowing the air, which it displaces, to escape by the stop-cock R'. The screw plug, with the milled head V, replaces the ordinary screw by which the key of the stop-cock may be made to press with more or less force, upon its conical seat.

Fig. 86 represents, in a side view, the apparatus just described. We here remark an air-cock n, and an opening *m*. At the extremity Q of the same figure, the conical pipe r enters, with friction. It is by this pipe that the air is sucked into the pipette when it is to be filled from its beak.
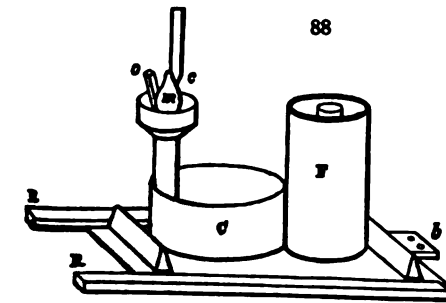
The *pipette* is supported by two horizontal arms H K (*fig.* 87) moveable about a common axis A A, and capable of being drawn out or shortened by the aid of two longitudinal slits. They are fixed steadily by two screw nuts *e é*, and their distance may be varied by means of round bits of wood or cork interposed, or even by opposite screw nuts *o ó*. The upper arm H is pierced with a hole, in which is fixed, by the pressure of a wooden screw *v*, the socket of the *pipette*. The corresponding hole of the lower arm is larger; and the beak of the *pipette* is supported in it by a cork stopper L. The apparatus is fixed by its tail-piece P, by means of a screw, to the corner of a wall, or any other prop.

The manner of filling the pipette is very simple. We begin by applying the fore-finger of the left hand to the lower aperture *c*; we then open the two stop-cocks R and R'. Whenever the liquor approaches the neck of the *pipette*, we must temper its influx, and when it has arrived at some millimetres above the mark *a b*, we close the two stop-cocks, and remove our fore-finger. We have now nothing more to do than to regulate the *pipette*; for which purpose the liquid must touch the line *a b*, and must simply adhere externally to the beak of the *pipette*.

This last circumstance is easily adjusted. After taking away the finger which closed the aperture *c* of the *pipette*, we apply to this orifice a moist sponge *m*, *fig.* 88, wrapped up in a linen rag, to absorb the superfluous liquor as it drops out. This sponge is called the handkerchief (*mouchoir*), by M. Gay Lussac. The *pipette* is said to be wiped when there is no liquor adhering to its point exteriorly.

For the convenience of operating, the handkerchief is fixed by friction in a tube of tin plate, terminated by a cup, open at bottom to let the droppings flow off into the cistern c, to which the tube is soldered. It may be easily removed for the purpose of washing it; and, if necessary, a little wedge of wood, *o*, can raise it toward the *pipette*.

To complete the adjustment of the *pipette*, the liquid must be made merely to descend to the mark *a*, *b*. With this view, and while the handkerchief is applied to the beak of the *pipette*, the air must be allowed to enter very slowly by unscrewing the plug v, *fig.* 85; and at the moment of the contact the handkerchief must be removed, and the bottle r, destined to receive the solution, must be placed below the orifice of the *pipette*, *fig.* 88. As the motion must be made rapidly, and without hesitation, the bottle is placed in a cylinder of tin-plate, of a diameter somewhat greater, and forming one body with the cistern and the handkerchief. The whole of this apparatus has for a basis a plate of tinned iron, moveable between two wooden rulers R R, one of which bears a groove, under which the edge of the plate slips. Its traverses are fixed by two abutments *b b*, placed so that when it is stopped by one of them, the beak of the *pipette* corresponds to the centre of the neck of the bottle, or is a tangent to the handkerchief. This arrangement, very convenient for wiping the *pipette* and emptying it, gives the apparatus sufficient solidity, and allows of its being taken away and replaced without deranging anything. It is obvious that it is of advantage, when once the entry of the air into the *pipette* has been regulated by the screw v, to leave it constantly open, because the

motion from the handkerchief to the bottle is performed with sufficient rapidity to prevent a drop of the solution from collecting and falling down.

Temperature of the Solution.—After having described the manner of measuring by volume the normal solution of the sea salt, we shall indicate the most convenient means of taking the temperature. The thermometer is placed in a tube of glass T, *fig.* 89, which the solution traverses to arrive at the *pipette.* It is suspended in it by a piece of cork, grooved on the four sides to afford passage to the liquid. The scale is engraved upon the tube itself, and is repeated at the opposite side, to fix the eye by the coincidence of this double division at the level of the thermometric column. The tube is joined below to another narrower one, through which it is attached by means of a cork stopper a, in the socket of the stop-cock of the *pipette.* At its upper part it is cemented into a brass socket, screw-tapped in the inside, which is connected in its turn by a cock, with the extremity, also tapped, of the tube above τ, belonging to the reservoir of the normal solution. The corks employed here as connecting links between the parts of the apparatus, give them a certain flexibility, and allow of their being dismounted and re-mounted in a very short time; but it is indispensable to make them be traversed by a hollow tube of glass or metal, which will hinder them from being crushed by the pressure they are exposed to. If the precaution be taken to grease them with a little suet, and to fill their pores, they will suffer no leakage.

Preservation of the Normal Solution of Sea Salt in metallic Vessels.—M. Gay Lussac uses for this purpose a cylindrical vessel or drum of copper, of a capacity of about 110 litres, having its inside covered with a rosin and wax cement.

Preparation of the Normal Solution of Sea Salt, measuring it by Volume.—If the drum contains 110 litres, we should put only 105 into it, in order that sufficient space may be left for agitating the liquor without throwing it out. According to the principle that 100 centimetres cube, or $\frac{1}{10}$ of a litre of the solution should contain enough of sea salt to precipitate a gramme of pure silver; and, admitting, moreover, 13·516 for the prime equivalent of silver, and 7·335 for that of sea salt, we shall find the quantity of pure salt that should be dissolved in the 105 litres of water, and which corresponds to $105 \times 10 = 1050$ grammes of silver, to be by the following proportion:—

$$13\cdot516 : 7\cdot335 :: 1050 \text{ gramm.} : x = 569\cdot83 \text{ gr.}$$

And as the solution of the sea salt of commerce, formerly mentioned, contains approximately 250 grammes per kilogramme, we must take 2279·3 grammes of this solution to have 569·83 gram. of salt. The mixture being perfectly made, the tubes and the *pipette* must be several times washed by running the solution through them, and putting it into the drum. The standard of the solution must be determined after it has been well agitated, supposing the temperature to remain uniform.

To arrive more conveniently at this result, we begin by preparing two *decime* solutions; one of silver, and another of sea salt.

The decime solution of silver is obtained by dissolving 1 gramme of silver in nitric acid, and diluting the solution with water till its volume becomes a litre.

The decime solution of sea salt may be obtained by dissolving 0·543 grammes of pure sea salt in water, so that the solution shall occupy a litre; but we shall prepare it even with the normal solution which we wish to test, by mixing a measure of it with 9 measures of water; it being understood that this solution is not rigorously equivalent to that of silver, and that it will become so, only when the normal solution employed for its preparation shall be finally of the true standard. Lastly, we prepare beforehand several stoppered vials, in each of which we dissolve 1 gramme of silver in 8 or 10 grammes of nitric acid. For brevity's sake we shall call these tests.

Now to investigate the standard of the normal solution, we must transfer a *pipette* of it into one of these test vials; and we must agitate the liquors briskly to clarify them. After some instants of repose, we must pour in 2 thousandths of the *decime* solution of sea salt, which, we suppose, will produce a precipitate. The normal liquor is consequently too feeble; and we should expect this, since the sea salt employed was not perfectly pure. We agitate and add 2 fresh thousandths, which will also produce a precipitate. We continue thus by successive additions of 2 thousandths, till the last produces no precipitation. Suppose that we have added 16 thousandths: the last two should not be reckoned, as they produced no precipitate; the preceding two were necessary, but only in part; that is to say, the useful thousandths added are above 12 and below 14, or otherwise they are on an average equal to 13.

Thus, in the condition of the normal solution, we require 1013 parts of it to precipitate one gramme of silver, while we should require only 1000. We shall find the quantity of concentrated solution of sea salt that we should add, by noting that the quantity of solution of sea salt, at first employed, viz. 2279·3 grammes, produced a standard of only 987 thousandths=1000—13; and by using the following proportion:

$$987 : 2279\cdot3 :: 13 : x = 30\cdot02 \text{ grammes.}$$

This quantity of the strong solution of salt, mixed with the normal solution in the drum, will correct its standard, and we shall now see by how much.

After having washed the tubes and the *pipette* with the new solution, we must repeat the experiment upon a fresh gramme of silver. We shall find, for example, in proceeding only by a thousandth at a time, that the first causes a precipitate, but not the second. The standard of the solution is still too weak, and is comprised between 1000 and 1001; that is to say, it may be equal to 1000½, but we must make a closer approximation.

We pour into the test bottle 2 thousandths of the *decime* solution of silver, which will destroy, perceptibly, two thousandths of sea salt, and the operation will have retrograded by two thousandths; that is to say, it will be brought back to the point at which it was first of all. If, after having cleared up the liquor, we add half a thousandth of the decime solution, there will necessarily be a precipitate, as we knew beforehand, but a second will cause no turbidity. The standard of the normal liquor will be consequently comprehended between 1000 and 1000½, or equal to 1000¼.

We should rest content with this standard, but if we wish to correct it, we may remark that the two quantities of solution of salt added, viz. 2279·3 gr. + 30·02 gr.= 2309·32 gr. have produced only 999·75 thousandths, and that we must add a new quantity of it corresponding to ¼ of a thousandth. We make, therefore, the proportion

$$999\cdot75 : 2309\cdot32 :: 0\cdot25 : x.$$

But since the first term differs very little from 1000, we may content ourselves to have x by taking the $\frac{0\cdot25}{1000}$ of 2309·32, and we shall find 0·577 gr. for the quantity of solution of sea salt to be added to the normal solution.

It is not convenient to take exactly so small a quantity of solution of sea salt by the balance, but we shall succeed easily by the following process. We weigh 50 grammes of this solution, and we dilute it with water; so that it occupies exactly half a litre, or 500 centimetres cube. A *pipette* of this solution, one centimetre cube in volume, will give a decigramme of the primitive solution, and as such a small *pipette* is divided into twenty drops, each drop, for example, will represent 5 milligrammes of the solution. We should arrive at quantities smaller still by diluting the solution with a proper quantity of water; but greater precision would be entirely needless.

The testing of the normal liquor just described, is, in reality, less tedious than might be supposed. It deserves also to be remarked, that liquor has been prepared for more than 1000 assays; and that, in preparing a fresh quantity, we shall obtain directly its true standard, or nearly so, if we bear in mind the quantities of water and solution of salt which had been employed.

Correction of the Standard of the Normal Solution of Sea Salt, when the Temperature changes.—We have supposed, in determining the standard of the normal solution of sea salt, that the temperature remained uniform. The assays made in such circumstances, have no need of correction; but if the temperature should change, the same measure of the solution will not contain the same quantity of sea salt. Supposing that we have tested the solution of the salt at the temperature of 15° C.; if, at the time of making the experiment, the temperature is 18° C., for example, the solution will be too weak on account of its expansion, and the *pipette* will contain less of it by weight; if, on the contrary, the temperature has fallen to 12°, the solution will be thereby concentrated and will prove too strong. It is therefore proper to determine the correction necessary to be made, for any variation of temperature.

To ascertain this point, the temperature of the solution of sea salt was made successively to be 0°, 5°, 10°, 15°, 20°, 25°, and 30° C.; and three *pipettes* of the solution were weighed exactly at each of these temperatures. The third of these weighings gave the mean weight of a *pipette*. The corresponding weights of a *pipette* of the solution, were afterwards graphically interpolated from degree to degree. These weights form the second column of the following table, entitled, *Table of Correction for the Variations in the Temperature of the Normal Solution of the Sea Salt*. They enable us to correct any temperature between 0 and 30 degrees centigrade (32° and 86° Fahr.) when the solution of sea salt has been prepared in the same limits.

Let us suppose, for example, that the solution has been made standard at 15°, and that, at the time of using it, the temperature has become 18°. We see by the second column of the table, that the weight of a measure of the solution is 100·099 gr. at 15°, and 100·065 at 18°; the difference 0·034 gr., is the quantity of solution less which has been really taken; and of course we must add it to the normal measure, in order to make it equal to one thousand *millièmes*. If the temperature of the solution had fallen to 10 degrees, the difference of the weight of a measure from 10 to 15 degrees would be 0·019 gr., which we must on the contrary deduct from the measure, since it had been taken too large. These differences of weight of a measure of solution at 15°, from that of a

measure at any other temperature, form the column 15° of the table, where they are expressed in thousandths; they are inscribed on the same horizontal lines as the temperatures to which each of them relates, with the sign + *plus*, when they must be added, and with the sign — *minus*, when they must be subtracted. The columns 5°, 10°, 20°, 25°, 35°, have been calculated in the same manner for the cases in which the normal solution may have been graduated to each of these temperatures. Thus, to calculate the column 10, the number 100·118 has been taken of the column of weights for a term of departure, and its difference from all the numbers of the same column has been sought.

Table of Correction for the Variations in the Temperature of the Normal Solution of the Sea Salt.

Temperature.	Weight.	5°	10°	15°	20°	25°	30°
	gram.	mill.	mill.	mill.	mill.	mill.	mill.
4	100,109	0·0	— 0·1	+ 0·1	+ 0·7	+ 1·7	+ 2·7
5	100,113	0·0	— 0·1	+ 0·1	+ 0·7	+ 1·7	+ 2·8
6	100,115	0·0	0·0	+ 0·2	+ 0·8	+ 1·7	+ 2·8
7	110,118	+ 0·1	0·0	+ 0·2	+ 0·8	+ 1·7	+ 2·8
8	100,120	+ 0·1	0·0	+ 0·2	+ 0·8	+ 1·8	+ 2·8
9	100,120	+ 0·1	0·0	+ 0·2	+ 0·8	+ 1·8	+ 2·8
10	100,118	+ 0·1	0·0	+ 0·2	+ 0·8	+ 1·7	+ 2·8
11	100,116	0·0	0·0	+ 0·2	+ 0·8	+ 1·7	+ 2·8
12	100,114	0·0	0·0	+ 0·2	+ 0·8	+ 1·7	+ 2·8
13	100,110	0·0	— 0·1	+ 0·1	+ 0·7	+ 1·7	+ 2·7
14	100,106	— 0·1	— 0·1	+ 0·1	+ 0·7	+ 1·6	+ 2·7
15	100,099	— 0·1	— 0·2	— 0·0	+ 0·6	+ 1·6	+ 2·6
16	100,090	— 0·2	— 0·3	— 0·1	+ 0·5	+ 1·5	+ 2·5
17	100,078	— 0·4	— 0·4	— 0·2	+ 0·4	+ 1·3	+ 2·4
18	100,065	— 0·5	— 0·5	— 0·3	+ 0·3	+ 1·2	+ 2·3
19	100,053	— 0·6	— 0·7	— 0·5	+ 0·1	+ 1·1	+ 2·2
20	100,039	— 0·7	— 0·8	— 0·6	0·0	+ 1·0	+ 2·0
21	100,021	— 0·9	— 1·0	— 0·8	— 0·2	+ 0·8	+ 1·9
22	100,001	— 1·1	— 1·2	— 1·0	— 0·4	+ 0·6	+ 1·7
23	99,983	— 1·3	— 1·4	— 1·2	— 0·6	+ 0·4	+ 1·5
24	99,964	— 1·5	— 1·5	— 1·4	— 0·8	+ 0·2	+ 1·3
25	99,944	— 1·7	— 1·7	— 1·6	— 1·0	0·0	+ 1·1
26	99,924	— 1·9	— 1·9	— 1·8	— 1·2	— 0·2	+ 0·9
27	99,902	— 2·1	— 2·2	— 2·0	— 1·4	— 0·4	+ 0·7
28	99,879	— 2·3	— 2·4	— 2·2	— 1·6	— 0·7	+ 0·4
29	99,858	— 2·6	— 2·6	— 2·4	— 1·8	— 0·9	+ 0·2
30	99,836	— 2·8	— 2·8	— 2·6	— 2·0	— 1·1	0·0

Several expedients have been employed to facilitate and abridge the manipulations. In the first place, the vials for testing or assaying the specimens of silver should all be of the same height and of the same diameter. They should be numbered at their top, as well as on their stoppers, in the order 1, 2, 3, &c. They may be ranged successively in tens; the stoppers of the same series being placed on a support in their proper order. Each two vials should, in their turn, be placed in a japanned tin case (*fig.* 90), with ten compartments duly numbered. These compartments are cut out anteriorly to about half their height, to allow the bottoms of the bottles to be seen. When each vial has received its portion of alloy, through a wide-beaked funnel, there must be poured into it about 10 grammes of nitric acid, of specific gravity 1·28, with a · pipette, containing that quantity; it is then exposed to the heat of a water bath, in order to facilitate the solution of the alloy. The water bath is an oblong vessel made of tin plate, intended to receive the vials. It has a moveable double bottom, pierced with small holes, for the purpose of preventing the vials being broken, as it insulates them from the bottom to which the heat is applied. The solution is rapid; and, since it emits nitrous vapors in abundance, it ought to be carried on under a chimney.

The agitator.—*Fig.* 91 gives a sufficiently exact idea of it, and may dispense with a lengthened description. It has ten cylindrical compartments, numbered from 1 to 10. The vials, after the solution of the alloy, are arranged in it in the order of their numbers. The agitator is then placed within reach of the *pipette*, intended to measure out the normal solution of sea salt, and a *pipette* full of this solution is put in each vial. Each is then closed with its glass stopper, previously dipped in pure water. They are fixed in the cells of the agitator by wooden wedges. The agitator is then suspended

to ... spring R, and, seizing it with the two hands, the operator gives an alternating rapid movement, which agitates the solution, and makes it, in less than a minute, as limpid as water. This movement is promoted by a spiral spring, B, fixed to the agitator and the ground, but this is seldom made use of, because it is convenient to be able to transport the agitator from one place to another. When the agitation is finished, the wedges are to be taken out, and the vials are placed in order upon a table furnished with round cells destined to receive them, and to screen them from too free a light.
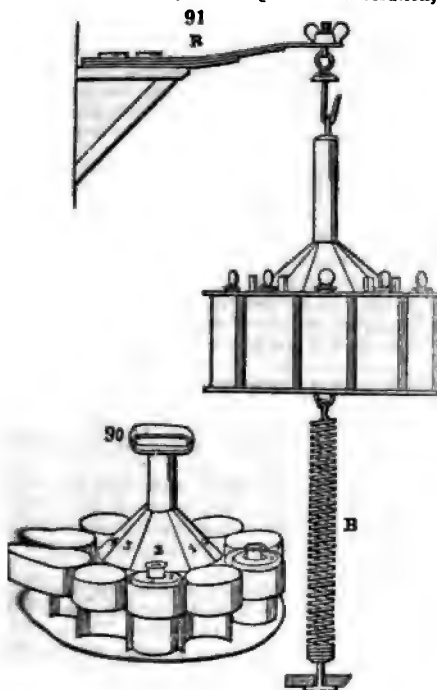
When we place the vials upon this table, we must give them a brisk circular motion, to collect the chloride of silver scattered round their sides; we must lift out their stoppers, and suspend them in wire rings, or pincers. We next pour a thousandth of the decime solution into each vial; and before this operation is terminated, there is formed in the first vials, when there *should be* a precipitate, a nebulous stratum, very well marked, of about a centimetre in thickness.

At the back of the table there is a black board divided into compartments numbered from 1 to 10, upon each of which we mark, with chalk, the thousandths of the decime liquor put into the correspondent vial. The thousandths of sea salt, which indicate an augmentation of standard, are preceded by the sign +, and the thousandths of nitrate of silver by the sign —.

When the assays are finished, the liquor of each vial is to be poured into a large vessel, in which a slight excess of sea salt is kept; and when it is full, the supernatant clear liquid must be run off with a syphon.

The chloride of silver may be reduced without any perceptible loss. After having washed it well, we immerse pieces of iron or zinc into it, and add sulphuric acid in sufficient quantity to keep up a feeble disengagement of hydrogen gas. The mass must not be touched. In a few days the silver is completely reduced. This is easily recognised by the color and nature of the product; or by treating a small quantity of it with water of ammonia, we shall see whether there be any chloride unreduced; for it will be dissolved by the ammonia, and will afterwards appear upon saturating the ammonia with an acid. The chlorine remains associated with the iron or the zinc in a state of solution. The first washings of the reduced silver must be made with an acidulous water, to dissolve the oxyde of iron which may have been formed, and the other washings with common water. After decanting the water of the last washing, we dry the mass, and add a little powdered borax to it. It must be now fused. The silver being in a bulky powder, is to be put in successive portions into a crucible as it sinks down. The heat should be at first moderate; but towards the end of the operation it must be pretty strong to bring into complete fusion the silver and the scoriæ, and to effect their complete separation. In case it should be supposed that the whole of the silver had not been reduced by the iron or zinc, a little carbonate of potash should be added to the borax. The silver may also be reduced by exposing the chloride to a strong heat, in contact with chalk and charcoal.

The following remarks by M. Gay Lussac, the author of the above method, upon the effect of a little mercury in the humid assay, are important:—

It is well known that chloride of silver blackens the more readily as it is exposed to an intense light, and that even in the diffused light of a room, it becomes soon sensibly colored. If it contains four to five thousandths of mercury, it does not blacken; it remains of a dead white: with three thousandths of mercury, there is no marked discoloring in diffused light; with two thousandths it is slight; with one it is much more marked, but still it is much less intense than with pure chloride. With half a

thousandth of mercury the difference of color is not remarkable, and is perceived only in a very moderate light.

But when the quantity of mercury is so small that it cannot be detected by the difference of color in the chloride of silver, it may be rendered quite evident by a very simple process of concentration. Dissolve one gramme of the silver supposed to contain $\frac{1}{4}$ of a thousandth of mercury, and let only $\frac{1}{4}$ of it be precipitated, by adding only $\frac{1}{4}$ of the common salt necessary to precipitate it entirely. In thus operating, the $\frac{1}{4}$ thousandth of mercury is concentrated in a quantity of chloride of silver four times smaller: it is as if the silver having been entirely precipitated, four times as much mercury, equal to two thousandths, had been precipitated with it.

In taking two grammes of silver, and precipitating only $\frac{1}{4}$ by common salt, the precipitate would be, with respect to the chloride of silver, as if it amounted to four thousandths. By this process, which occupies only five minutes, because exact weighing is not necessary, $\frac{1}{10}$ of a thousandth of mercury may be detected in silver.

It is not useless to observe, that in making those experiments the most exact manner of introducing small quantities of mercury into a solution of silver, is to weigh a minute globule of mercury, and to dissolve it in nitric acid, diluting the solution so that it may contain as many cubic centimetres as the globule weighs of centigrammes. Each cubic centimetre, taken by means of a *pipette*, will contain one milligramme of mercury.

If the ingot of silver to be assayed is found to contain a greater quantity of mercury, one thousandth for example, the humid process ought either to be given up in this case, or to be compared with cupellation.

When the silver contains mercury, the solution from which the mixed chlorides are precipitated does not readily become clear.

Silver containing mercury, put into a small crucible and mixed with lamp-black, to prevent the volatilization of the silver, was heated for three quarters of an hour in a muffle, but the silver increased sensibly in weight. This process for separating the mercury, therefore, failed. It is to be observed, that mercury is the only metal which has thus the power of disturbing the analysis by the humid way.

ASSAYING OF GOLD.—In estimating or expressing the fineness of gold, the whole mass spoken of is supposed to weigh 24 carats of 12 grains each, either real, or merely proportional, like the assayer's weights; and the pure gold is called fine. Thus, if gold be said to be 23 carats fine, it is to be understood, that in a mass, weighing 24 carats, the quantity of pure gold amounts to 23 carats.

In such small work as cannot be assayed by scraping off a part and cupelling it, the assayers endeavor to ascertain its fineness or quality by the touch. This is a method of comparing the color and other properties, of a minute portion of the metal, with those of small bars, the composition of which is known. These bars are called touch needles, and they are rubbed upon a smooth piece of black basaltes or pottery, which, for this reason, is called the touchstone. Black flint slate will serve the same purpose. Sets of gold needles may consist of pure gold; of pure gold, 23$\frac{1}{2}$ carats with $\frac{1}{2}$ carat of silver; 23 carats of gold with one carat of silver; 22$\frac{1}{2}$ carats of gold with 1$\frac{1}{2}$ carat of silver; and so on, till the silver amounts to four carats; after which the additions may proceed by whole carats. Other needles may be made in the same manner, with copper instead of silver; and other sets may have the addition, consisting either of equal parts of silver and copper, or of such proportions as the occasions of business require. The examination by the touch may be advantageously employed previous to quartation, to indicate the quantity of silver necessary to be added.

In foreign countries, where trinkets and small work are required to be submitted to the assay of the touch, a variety of needles is necessary; but they are not much used in England. They afford, however, a degree of information which is more considerable than might at first be expected. The attentive assayer compares not only the color of the stroke made upon the touchstone by the metal under examination, with that produced by his needle, but will likewise attend to the sensation of roughness, dryness, smoothness, or greasiness, which the texture of the rubbed metal excites, when abraded by the stone. When two strokes perfectly alike in color are made upon the stone, he may then wet them with aquafortis, which will affect them very differently, if they be not similar compositions; or the stone itself may be made red-hot by the fire, or by the blowpipe, if thin black pottery be used; in which case the phenomena of oxydation will differ according to the nature and quantity of the alloy. Six principal circumstances appear to affect the operation of parting; namely, the quantity of acid used in parting, or in the first boiling; the concentration of this acid; the time employed in its application; the quantity of acid made use of in the *reprise*, or second operation; its concentration; and the time during which it is applied. From experiment it has been shown, that each of these unfavorable circumstances might easily occasion a loss of from the half of

a thirty-second part of a carat, to two thirty-second parts. The assayers explain their technical language by observing, that in the whole mass consisting of twenty-four carats, this thirty-second part denotes 1-768th part of the mass. It may easily be conceived, therefore, that if the whole six circumstances were to exist, and be productive of errors, falling the same way, the loss would be very considerable.

It is therefore indispensably necessary, that one uniform process should be followed in the assays of gold; and it is a matter of astonishment, that such an accurate process should not have been prescribed by government for assayers, in an operation of such great commercial importance, instead of every one being left to follow his own judgment. The process recommended in the old French official report is as follows:— twelve grains of the gold intended to be assayed must be mixed with thirty grains of fine silver, and cupelled with 108 grains of lead. The cupellation must be carefully attended to, and all the imperfect buttons rejected. When the cupellation is ended, the button must be reduced, by lamination, into a plate of 1½ inches, or rather more, in length, and four or five lines in breadth. This must be rolled up upon a quill, and placed in a matrass capable of holding about three ounces of liquid, when filled up to its narrow part. Two ounces and a half of very pure aquafortis, of the strength of 20 degrees of Baumé's areometer, must then be poured upon it; and the matrass being placed upon hot ashes, or sand, the acid must be kept gently boiling for a quarter of an hour: the acid must then be cautiously decanted, and an additional quantity of 1½ ounces must be poured upon the metal, and slightly boiled for twelve minutes. This being likewise carefully decanted, the small spiral piece of metal must be washed with filtered river water, or distilled water, by filling the matrass with this fluid. The vessel is then to be reversed, by applying the extremity of its neck against the bottom of a crucible of fine earth, the internal surface of which is very smooth. The annealing must now be made, after having separated the portion of water which had fallen into the crucible; and, lastly, the annealed gold must be weighed. For the certainty of this operation, two assays must be made in the same manner, together with a third assay upon gold of twenty-four carats, or upon gold the fineness of which is perfectly and generally known.

No conclusion must be drawn from this assay, unless the latter gold should prove to be of the fineness of twenty-four carats exactly, or of its known degree of fineness; for, if there be either loss or surplus, it may be inferred that the other two assays, having undergone the same operation, must be subject to the same error. The operation being made according to this process by several assayers, in circumstances of importance, such as those which relate to large fabrications, the fineness of the gold must not be depended upon, nor considered as accurately known, unless all the assayers have obtained a uniform result, without communication with each other. This identity must be considered as referring to the accuracy of half the thirty-second part of a carat. For, notwithstanding every possible precaution or uniformity, it very seldom happens that an absolute agreement is obtained between the different assays of one and the same ingot; because the ingot itself may differ in its fineness in different parts of its mass.

The phenomena of the cupellation of gold are the same as of silver, only the operation is less delicate, for no gold is lost by evaporation or penetration into the bone-ash, and therefore it bears safely the highest heat of the assay furnace. The button of gold never vegetates, and need not therefore be drawn out to the front of the muffle, but may be left at the further end till the assay is complete. Copper is retained more strongly by gold than it is by silver; so that with it 16 parts of lead are requisite to sweat out 1 of copper; or, in general, twice as much lead must be taken for the copper alloys of gold, as for those of silver. When the copper is alloyed with very small quantities of gold, cupellation would afford very uncertain results; we must then have recourse to liquid analysis.

M. Vauquelin recommends to boil 60 parts of nitric acid at 22° Baumé, on the spiral tip or cornet of gold and silver alloy, for twenty-five minutes, and replace the liquid afterwards by acid of 32°, which must be boiled on it for eight minutes. This process is free from uncertainty when the assay is performed upon an alloy containing a considerable quantity of copper. But this is not the case in assaying finer gold; for then a little silver always remains in the gold. The surcharge which occurs here is 2 or 3 thousandths; this is too much, and it is an intolerable error when it becomes greater, which often happens. This evil may be completely avoided by employing the following process of M. Chaudet. He takes 0·500 of the fine gold to be assayed; cupels it with 1·500 of silver, and 1·000 of lead; forms, with the button from the cupel, a riband or strip three inches long, which he rolls into a cornet. He puts this into a matrass with acid at 22° B., which he boils for 3 or 4 minutes. He replaces this by acid of 32° B., and boils for ten minutes; then decants off, and boils again with acid of 32°, which must be finally boiled for 9 or 10 minutes.

Gold thus treated is very pure. He washes the cornet, and puts it entire into a small

crucible permeable to water; heats the crucible to dull redness under the muffle, when the gold assumes the metallic lustre, and the cornet becomes solid. It is now taken out of the crucible and weighed.

When the alloy contains platinum, the assay presents greater difficulties. In general, to separate the platinum from the gold with accuracy, we must avail ourselves of a peculiar property of platinum; when alloyed with silver, it becomes soluble in nitric acid. Therefore, by a proper quartation of the alloy by cupellation, and boiling the button with nitric acid, we may get a residuum of pure gold. If we were to treat the button with sulphuric acid, however, we should dissolve nothing but the silver. The copper is easily removed by cupellation. Hence, supposing that we have a quaternary compound of copper, silver, platinum, and gold, we first cupel it, and weigh the button obtained; the loss denotes the copper. This button, treated by sulphuric acid, will suffer a loss of weight equal to the amount of silver present. The residuum, by quartation with silver and boiling with nitric acid, will part with its platinum, and the gold will remain pure. For more detailed explanations, see PLATINUM.

ATOMIC WEIGHTS or ATOMS, are the primal quantities in which the different objects of chemistry, simple or compound, combine with each other, referred to a common body, taken as unity. Oxygen is assumed by some philosophers, and hydrogen by others, as the standard of comparison. Every chemical manufacturer should be thoroughly acquainted with the combining ratios, which are, for the same two substances, not only definite, but multiple; two great truths, upon which are founded not merely the *rationale* of his operations, but also the means of modifying them to useful purposes. The discussion of the doctrine of atomic weights, or prime equivalents, belongs to pure chemistry; but several of its happiest applications are to be found in the processes of art, as pursued upon the greatest scale. For many instructive examples of this proposition, the various chemical manufactures may be consulted in this Dictionary.

ATTAR OF ROSES. See OILS, VOLATILE, and PERFUMERY.

AURUM MUSIVUM. Mosaic gold, a preparation of tin; which see.

AUTOMATIC, a term which I have employed to designate such economic arts as are carried on by self-acting machinery. The word "manufacture," in its etymological sense, means any system, or objects of industry, executed by the hands; but in the vicissitude of language, it has now come to signify every extensive product of art which is made by machinery, with little or no aid of the human hand, so that the most perfect manufacture is that which dispenses entirely with manual labor.[*] It is in our modern cotton and flax mills that automatic operations are displayed to most advantage; for there the elemental powers have been made to animate millions of complex organs, infusing into forms of wood, iron, and brass, an intelligent agency. And as the philosophy of the fine arts, poetry, painting, and music, may be best studied in their individual master-pieces, so may the philosophy of manufactures in these its noblest creations.[†]

The constant aim and effect of these automatic improvements in the arts are philanthropic, as they tend to relieve the workmen either from niceties of adjustment, which exhaust his mind and fatigue his eyes, or from painful repetition of effort, which distort and wear out his frame. A well-arranged power-mill combines the operation of many work-people, adult and young, in tending with assiduous skill a system of productive machines continuously impelled by a central force. How vastly conducive to the commercial greatness of a nation, and the comforts of mankind, human industry can become, when no longer proportioned in its results to muscular effort, which is by its nature fitful and capricious, but when made to consist in the task of guiding the work of mechanical fingers and arms regularly impelled, with equal precision and velocity, by some indefatigable physical agent, is apparent to every visiter of our cotton, flax, silk, wool, and machine factories. This great era in the useful arts is mainly due to the genius of Arkwright. Prior to the introduction of his system, manufactures were everywhere feeble and fluctuating in their development; shooting forth luxuriantly for a season, and again withering almost to the roots like annual plants. Their perennial growth then began, and attracted capital, in copious streams, to irrigate the rich domains of industry. When this new career commenced, about the year 1770, the annual consumption of cotton in British manufactures was under four millions of pounds weight, and that of the whole of Christendom was probably not more than ten millions. Last year the consumption in Great Britain and Ireland was about two hundred and seventy millions of pounds, and that of Europe and the United States together, four hundred and eighty millions. In our spacious factory apartments the benignant power of steam summons around him his myriads of willing menials, and assigns to each the regulated task, substituting, for painful muscular effort upon their part, the energies of his own gigantic arm, and demanding, in return, only attention and dexterity to correct such little aberrations as casually occur in his workmanship. Under his auspices,

* Philosophy of Manufactures, p. 1.   † Ibid., p. 2.

and in obedience to Arkwright's polity, magnificent edifices, surpassing far in number, value, usefulness, and ingenuity of construction, the boasted monuments of Asiatic, Egyptian, and Roman despotism, have, within the short period of fifty years, risen up in this kingdom, to show to what extent capital, industry, and science, may augment the resources of a state, while they meliorate the condition of its citizens. Such is the automatic system, replete with prodigies in mechanics and political economy, which promises, in its future growth, to become the great minister of civilization to the terraqueous globe, enabling this country, as its heart, to diffuse, along with its commerce, the life-blood of knowledge and religion to myriads of people still lying " in the region and shadow of death."* Of these truths, the present work affords decisive evidence in almost every page.

AUTOMATON. In the etymological sense, this word (self-working) signifies every mechanical construction which, by virtue of a latent intrinsic force, not obvious to common eyes, can carry on, for some time, certain movements more or less resembling the results of animal exertion, without the aid of external impulse. In this respect, all kinds of clocks and watches, planetariums, common and smoke jacks, with a vast number of the machines now employed in our cotton, silk, flax, and wool factories, as well as in our dyeing and calico printing works, may be denominated automatic. But the term, automaton, is, in common language, appropriated to that class of mechanical artifices in which the purposely concealed power is made to imitate the arbitrary or voluntary motions of living beings. Human figures, of this kind, are sometimes styled *Androides*, from the Greek term, *like a man*.

Although, from what we have said, clock-work is not properly placed under the head automaton, it cannot be doubted that the art of making clocks, in its progressive improvement and extension, has given rise to the production of automata. The most of these, in their interior structure, as well as in the mode of applying the moving power, have a distinct analogy with clocks; and these automata are frequently mounted in connexion with watch work. Towards the end of the 13th century, several tower clocks, such as those at Strasburg, Lubec, Prague, Olmutz, had curious mechanisms attached to them. The most careful historical inquiry proves that automata, properly speaking, are certainly not older than *wheel*-clocks; and that the more perfect structures of this kind are subsequent to the general introduction of *spring*-clocks. Many accounts of ancient automata, such as the flying doves of Archytas of Tarentum, Regiomontanus's iron flies, the eagle which flew towards the emperor Maximilian, in Nuremburg, in the year 1470, were deceptions, or exaggerated statements; for, three such masterpieces of art would form now, with every aid of our improved mechanisms, the most difficult of problems. The imitation of flying creatures is extremely difficult, for several reasons. There is very little space for the moving power, and the only material possessed of requisite strength being metal, must have considerable weight. Two automata, of the celebrated French mechanician, Vaucauson, first exhibited in the year 1738, have been greatly admired; namely, a flute-player, five and a half feet high, with a cubical pedestal, which played several airs upon the German flute; and that, not by any interior tube-work, but through the actual blowing of air into the flute, the motion of the tongue, and the skilful stopping of the holes with the fingers; as also a duck, which imitated many motions of a natural kind in the most extraordinary manner. This artist has had many imitators, of whom the brothers Droz of Chaux de Fonds were the most distinguished. Several very beautiful clock mechanisms of theirs are known. One of them with a figure which draws; another playing on the piano; a third which writes, besides numerous other combined automata. Frederick Von Knauss completed a writing machine at Vienna, in the year 1760. It is now in the model cabinet of the Polytechnic Institute, and consists of a globe 2 feet in diameter, containing the mechanism, upon which a figure 7 inches high sits, and writes upon a sheet of paper fixed to a frame, whatever has been placed beforehand upon a regulating cylinder. At the end of every line, it rises and moves its hand sideways, in order to begin a new line.

Very complete automata have not been made of late years, because they are very expensive; and by soon satisfying curiosity, they cease to interest. Ingenious mechanicians find themselves better rewarded by directing their talents to the self-acting machinery of modern manufactures. We may notice here, however, the mechanical trumpeter of Malzl, at Vienna, and a similar work of Kauffmann, at Dresden. In French Switzerland some artists continue to make minute automata which excite no little wonder; such as singing canary birds, with various movements of a natural kind; the little birds, sometimes hardly three quarters of an inch long, in snuff-boxes and watches of enamelled gold. Certain artificial figures which have been denominated automata, hardly deserve the name; since trick and confederacy are more or less con-

* Philosophy of Manufactures, p. 18.

cerned in their operation. To this head belong a number of figures apparently speaking by mechanism; a clock which begins to strike, or to play, when a person makes a sign of holding up his finger; this effect being probably produced by a concealed green-finch, or other little bird, instructed to set off the *détente* of the wheel-work at a signal. It is likely, also, that the chess player of Von Kempelen, which excited so much wonder in the last century, had a concealed confederate. Likewise, the very ingenious little figures of Tendler, father and son, which imitated English horsemen and rope-dancers, constructed at Eisenerz, in Styria, are probably no more true automata than the *fantoccini*, or figures of puppets which are exhibited in great perfection in many towns of Italy, especially at Rome.

The moving power of almost all automata is a wound-up steel spring; because in comparison with other means of giving motion, it takes up the smallest room, is easiest concealed, and set a-going. Weights are seldom employed, and only in a partial way. The employment of other moving powers is more limited; sometimes fine sand is made to fall on the circumference of a wheel, by which the rest of the mechanism is moved. For the same purpose water has been employed; and, when it is made to fall into an air-chamber, it causes sufficient wind to excite musical sounds in pipes. In particular cases quicksilver has been used, as, for example, in the Chinese tumblers, which is only a physical apparatus to illustrate the doctrine of the centre of gravity.

Figures are frequently constructed for playthings which move by wheels hardly visible. An example of this simplest kind of automaton which may be introduced here, as illustrating the self-acting principles of manufactures, is shown in the figure.

Fig. 92 exhibits the outlines of an automaton, representing a swan, with suitably combined movements. The mechanism may be described, for the sake of clearness
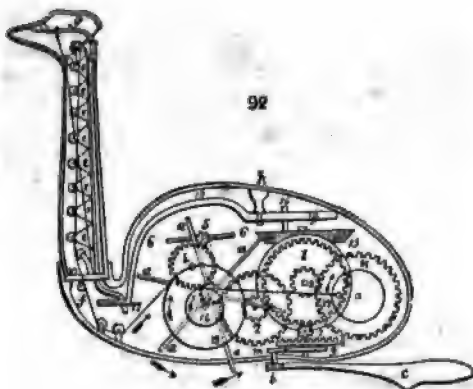
of explanation, under distinct heads. The first relates to the motion of the whole figure. By means of this part it swims upon the water, in directions changed from time to time without exterior agency. Another construction gives to the figure the faculty of bending its neck on several occasions, and to such an extent that it can plunge the bill and a portion of the head under water. Lastly, it is made to move its head and neck slowly from side to side.

On the barrel of the spring-wheel, there is a main-wheel, marked 1, which works into the pinion of the wheel 2. The wheel 2 moves a smaller one, shown merely in dotted lines, and on the long axis of the latter, at either end there is a rudder, or water-wheel, the paddles of which are denoted by the letter *a*. Both of these rudder-wheels extend through an oblong opening in the bottom of the figure down into the water. They turn in the direction of the arrow, and impart a straight-forward movement to the swan. The chamber, in which these wheels revolve, is made water tight, to prevent moisture being thrown upon the rest of the machinery. By the wheel 4, motion is conveyed to the fly-pinion 5; the fly itself 6, serves to regulate the working of the whole apparatus, and it is provided with a stop bar not shown in the engraving, to bring it to rest, or set it a-going at pleasure. Here, as we may imagine, the path pursued is rectilinear, when the rudder-wheels are made to work in a square direction. An oblique bar, seen only in section at *b*, moveable about its middle point, carries at each end a web foot *c*, so that the direction of the bar *b*, and of both feet towards the rudder wheels, determines the form of the path which the figure will describe. The change of direction of that oblique bar is effected without other agency. For this purpose the wheel 1 takes into the pinion 7, and this carries round the crown-wheel 8, which is fixed, with an eccentric disc 9, upon a common axis. While the crown-wheel moves in the direction of the arrow, it turns the smaller eccentric portion of the elliptic disc towards the lever *m*, which, pressed upon incessantly by its spring, assumes, by degrees, the position corresponding with the middle line of the figure, and afterwards an oblique position; then it goes back again, and reaches its first situation; consequently, through the reciprocal turning of the bar *k*, and the swim-foot, is determined and varied the path which the swan must pursue. This construction is available with all automata, which work by wheels; and it is ob-

views, that we may, by different forms of the disc 9, modify, at pleasure, the direction and the velocity of the turnings. If the disc is a circle, for instance, then the changes will take place less suddenly; if the disc has an outward and inward curvature, upon whose edge the end of the lever presses with a roller, the movement will take place in a serpentine line.

The neck is the part which requires the most careful workmanship. Its outward case must be flexible, and the neck itself should therefore be made of a tube of spiral wire, covered with leather, or with a feathered bird-skin. The double line in the interior, where we see the triangles *e, e, e,* denotes a steel spring made fast to the plate 10, which forms the bottom of the neck; it stands loose, and needs to be merely so strong as to keep the neck straight, or to bend it a little backwards. It should not be equally thick in all points, but it should be weaker where the first graceful bend is to be made; and, in general, its stiffness ought to correspond to the curvature of the neck of this bird. The triangles *e* are made fast at their base to the front surface of the spring; in the points of each there is a slit, in the middle of which a moveable roller is set, formed of a smoothly turned steel rod. A thin catgut string *f*, runs from the upper end of the spring, where it is fixed over all these rollers, and passes through an aperture pierced in the middle of 10, into the inside of the rump. If the catgut be drawn straight back towards *f*, the spring, and consequently the neck, must obviously be bent, and so much the more, the more tightly *f* is pulled, and is shortened in the hollow of the neck. How this is accomplished by the wheel-work will presently be shown. The wheel 11 receives its motion from the pinion *s*, connected with the main-wheel 1. Upon 11 there is, moreover, the disc 12, to whose circumference a slender chain is fastened. When the wheel 11 turns in the direction of the arrow, the chain will be so much pulled onwards through the corresponding advance at the point at 12, till this point has come to the place opposite to its present situation, and, consequently, 11 must have performed half a revolution. The other end of the chain is hung in the groove of a very moveable roller 14; and this will be turned immediately by the unwinding of the chain upon its axis. There turns, in connexion with it, however, the large roller 13, to which the catgut *f* is fastened; and as this is pulled in the direction of the arrow, the neck will be bent until the wheel 11 has made a half revolution. Then the drag ceases again to act upon the chain and the catgut; the spring in the neck comes into play: it becomes straight, erects the neck of the animal, and turns the rollers 13 and 14, back into their first position.

The roller 13 is of considerable size, in order that through the slight motion of the roller 14, a sufficient length of the catgut may be wound off, and the requisite shortening of the neck may be effected; which results from the proportion of the diameters of the rollers 11, 13, and 14. This part of the mechanism is attached as near to the side of the hollow body as possible, to make room for the interior parts, but particularly for the paddle-wheels. Since the catgut, *f*, must pass downwards on the middle from 10, it is necessary to incline it sideways and outwards towards 13, by means of some small rollers.

The head, constituting one piece with the neck, will be depressed by the complete texture of this; and the bill, being turned downwards in front of the breast, will touch the surface of the water. The head will not be motionless; but it is joined on both sides by a very moveable hinge, with the light ring, which forms the upper part of the clothing of the neck. A weak spring, *g*, also fastened. to the end of the neck, tends to turn the head backwards; but in the present position it cannot do so, because a chain at *g*, whose other end is attached to the plate 10, keeps it on the stretch. On the bending of the neck, this chain becomes slack; the spring *g* comes into operation, and throws the head so far back, that, in its natural position, it will reach the water.

Finally, to render the turning of the head and the neck practicable, the latter is not closely connected with the rump, while the plate 10 can turn in a cylindrical manner upon its axis, but cannot become loose outwardly. Moreover, there is upon the axis of the wheel 1, and behind it (shown merely as a circle in the engraving) a bevel wheel, which works into a second similar wheel, 15, so as to turn it in a horizontal direction. The pin 16, of the last wheel, works upon a two-armed lever 19, moveable round the point *h*, and this lever moves the neck by means of the pin 17. The shorter arm of the lever 19 has an oval aperture in which the pin 16 stands. As soon as this, in consequence of the movement of the bevel wheel 15, comes into the dotted position, it pushes the oval ring outwards on its smaller diameter, and thereby turns the lever upon the point *h*, into the oblique direction shown by the dotted lines. The pin 16, having come in its way right opposite to its present position, sets the lever again straight. Then the lever, by the further progress of the pin in its circular path, is directed outwards to the opposite side; and, at last, when 15 has made an entire revolution, it is quite straight. The longer arm of the lever follows, of course, these alternating movements, so that it turns the neck upon its plate 10, by means of the pin 17; and, as 18 denotes the bill,

this comes into the dotted position. It may be remarked in conclusion, that the drawing of *fig.* 92 represents about half the size of which the automaton may be constructed, and that the body may be formed of thin sheet-copper or brass.

Figs. 93 94 95, show the plan of a third automaton. A horse which moves its feet
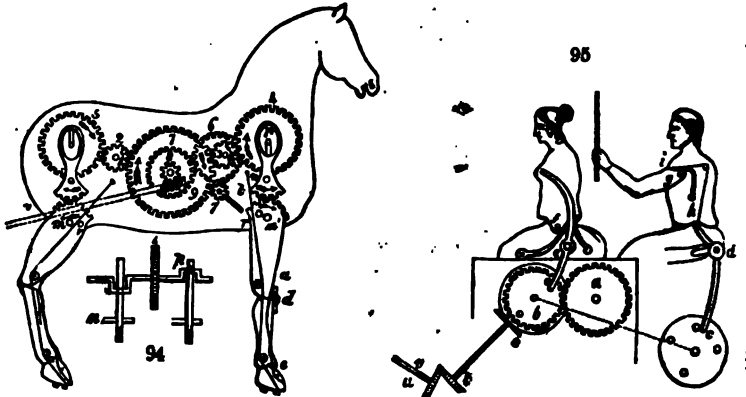
in a natural way, and draws a carriage with two figures sitting in it. The man appears to drive the horse with a whip; the woman bends forward from him in front. The four wheels of the carriage have no connexion with the moving mechanism. In *fig.* 95, some parts are represented upon a larger scale. The wheel 1, in *fig.* 93, operates through the two carrier wheels upon the wheels marked 4 and 5. By means of the axis of these two wheels, the feet are set in motion. The left fore-foot, *a*, then the right hinder foot, move themselves backwards, and take hold of the ground with small tacks in their hoofs, while the two other legs are bent and raised, but no motion of the body takes place. The carriage, however, with which the horse is connected, advances upon its wheels. By studying the mechanism of the foot, *a*, and the parts connected with it, we can readily understand the principles of the movement. The axis of wheel 4 is crank-shaped on both sides, where it has to operate directly on the fore feet; but for each foot, it is bent in an opposite direction, as is obvious in the front view *fig.* 94. This crank, or properly its part furthest from the axis, serves instead of the pin 16, in the swan, and moves like it in an oval spot, *p*, *fig.* 93, a two-armed lever, which gives motion through tooth-work, but not as in the swan, by means of a second pin. This wheelwork renders the motion smoother. The above lever has its fulcrum at *n*, *fig.* 93, about which it turns alternately, to the one and the other side, by virtue of the rotation of the wheel 4. The toothed arch, or the half-wheel on the under side, lays hold of a shorter lever, in a similar arch, upon the upper joint of the foot, which is moved forward and backward upon the pivot *m*. In virtue of the motions in the direction of the arrow, the foot *a* will move itself first obliquely backwards, without bending, and the body will thereby bend itself forward. When the right hand foot makes the same motion, both the other feet are raised and bent. The joints of the foot at *d* and *e* are formed of hinges, which are so constructed that they can yield no farther than is necessary at every oblique position of the foot. With the continued rotation of the wheel 4, the lever turns itself about *n*, in an inverted direction inwards, and impels the uppermost foot-joint forward, so that it forms an acute angle with the body in front. The foot is now twice bent upon its joints. This takes place by the traction of the chain *t*, which is led over rollers (as the drawing shows) to the foot, and is there fastened. As its upper end has its fixed point in the interior of the body, it is therefore drawn by the eccentric pin *r* standing in the vicinity of *m*, and thus bends the foot at the hinges. If there was space for it, a roller would answer better than a pin. By the recedure of the uppermost joint into the first position, the tension of the chain *t* ceases again of itself, while the pin *r* removes from it, and the foot is again extended in a straight line by the small springs operating upon its two under parts, which were previously bent stiffly by the chain. By the aid of the figures, with this explanation, it will be apparent that all the fore feet have a similar construction, that the proper succession of motions will be effected through the toothed arcs, and the position of the cranks on the axis of the wheels 4 and 5, and hence the advance of the figure must follow. The wheel 6 puts the fly 7 in motion, by means of the small wheel marked 1; in the fixed points of the 4 chains, by means of a ratchet-wheel and a catch, the

necessary tension will again be produced when the chains have been drawn out a little. There is sufficient room for a mechanism which could give motion to the head and ears, were it thought necessary.

The proper cause of the motions may now be explained. In *fig.* 95, *a* is a wheel connected with the wound-up spring, by which the motion of the two human figures, and also, if desired, that of the horse may be effected. The axis of the wheel *b* carries a disc with pins, which operate upon the two-armed lever with its fulcrum *e*, and thus cause the bending of the upper part of one of the figures, which has a hinge at *f*. On the axis of that wheel there is a second disc *c*, for giving motion to the other figure ; which, for the sake of clearness, is shown separate, although it should sit alongside of its fellow. On the upper end of the double-armed lever *d*, there is a cord whose other end is connected with the moving arm, in the situation *i*, and raises it whenever a pin in the disc presses the under part of the lever. A spring *h* brings the arm back into the original position, when a pin has passed from the lever, and has left it behind. The pins at *c* and *d* may be set at different distances from the middle of the disc, whereby the motions of the figures by every contact of another pin are varied, and are therefore not so uniform, and consequently more natural.

For the connexion of both mechanisms, namely, the carriage with the horse, various arrangements may be adopted. Two separate traction springs should be employed ; one at *a, fig.* 95, in the coach-seat ; the other in the body of the horse. In the coach-seat at *b*, the fly with its pinion, as well as a ratchet-wheel, is necessary. By means of the shaft, the horse is placed in connexion with the wagon. It may, however, receive its motion from the spring in the carriage, in which case one spring will be sufficient. Upon the latter plan the following construction may be adopted :—To the axis of *b*, *fig.* 95, a bevel wheel is to be attached, and from this the motion is to be transmitted to the bottom of the carriage with the help of a second bevel wheel *s*, connected with a third bevel wheel *t*. This again turns the wheel *u*, whose long axis *v* goes to the middle of the horse's body, in an oblique direction, through the hollow shaft. This axis carries an endless screw 9, *fig.* 93, with very oblique threads, which works into the little wheel 8, corresponding to the wheel 1, through an opening in the side of the horse, and in this way sets the mechanism of the horse a-going. With this construction of *fig.* 95, a spring of considerable strength is necessary, or if the height of the carriage-seat does not afford sufficient room, its breadth will answer for placing two weaker springs along-side of each other upon a common barrel.

AXE. A tool much used by carpenters for cleaving, and roughly fashioning, blocks of wood. It is a flat iron wedge, with an oblong steel edge, parallel to which, in the short base, is a hole for receiving and holding fast the end of a strong wooden handle. In the cooper's *adze*, the oblong edge is at right angles to the handle, and is slightly curved up, or inflected towards it.

AXLES, of carriages ; for their latest improvements, see WHEEL CARRIAGES.

AXUNGE. Hog's lard ; see FAT and OILS.

AZOTIZED, said of certain vegetable substances, which, as containing azote, were supposed at one time to partake, in some measure, of the animal nature ; most animal bodies being characterized by the presence of much azote in their composition. The vegetable products, indigo, cafeine, gluten, and many others, contain abundance of azote.

AZURE, the fine blue pigment, commonly called smalt, is a glass colored with oxyde of cobalt, and ground to an impalpable powder.

The manufacture of azure, or smalt, has been lately improved in Sweden, by the adoption of the following process :—

The cobalt ore is first roasted till the greater part of the arsenic is driven off. The residuary impure black oxyde is mixed with as much sulphuric acid (concentrated) as will make it into a paste, which is exposed at first to a moderate heat, then to a cherry-red ignition for an hour. The sulphate thus obtained is reduced to powder, and dissolved in water. To the solution, carbonate of potash is gradually added, in order to separate the remaining portion of oxyde of iron ; the quantity of which depends upon the previous degree of calcination. If it be not enough oxydized, the iron is difficult to be got rid of.

When, from the color of the precipitate, we find that the potash separates merely carbonate of cobalt, it is allowed to settle, the supernatant liquor is decanted, and precipitated, by means of a solution of silicate of potash, prepared as follows :—

Ten parts of potash are carefully mixed with fifteen parts of finely ground flints or sand, and one part of pounded charcoal. This mixture is melted in a crucible of brick clay, an operation which requires steady ignition during 5 or 6 hours. The mass, when melted and pulverized, may be easily dissolved in boiling water, adding to it, by little at a time, the glass previously ground. The filtered solution is colorless, and keeps well in the air, if it contains one part of glass for 5 or 6 of water. The silicate

of cobalt, which precipitates upon mixing the two solutions, is the preparation of cobalt most suitable for painting upon porcelain, and for the manufacture of blue glass. See COBALT.

B.

BABLAH. The rind or shell which surrounds the fruit of the *mimosa cineraria*; it comes from the East Indies, as also from Senegal, under the name of Neb-neb. It contains gallic acid, tannin, a red coloring matter, and an azotized substance; but the proportion of tannin is smaller than in sumach, galls, and *knoppern* (gall-nuts of the common oak) in reference to that of gallic acid, which is considerable in the bablah. It has been used, in dyeing cotton, for producing various shades of drab; as a substitute for the more expensive astringent dye-stuffs.

BAGASSE. The sugar-cane, in its dry, crushed state, as delivered from the sugar-mill. It is much employed for fuel in the colonial sugar-houses.

BAKING. (*Cuire*, Fr. *Backen*, Germ.) The exposure of any body to such a heat as will dry and consolidate its parts without wasting them. Thus, wood, pottery, and porcelain, are baked, as well as bread.

BALANCE. To conduct arts, manufactures, and mines, with judgment and success, recourse must be had, at almost every step, to a balance. Experience proves that all material bodies, existing upon the surface of the earth, are constantly solicited by a force which tends to bring them to its centre, and that they actually fall towards it when they are free to move. This force is called gravity. Though the bodies be not free, the effort of gravity is still sensible, and the resultant of all the actions which it exercises upon their material points, constitutes what is popularly called their *weight*. These weights are, therefore, forces which may be compared together, and by means of machines may be made to correspond or be counterpoised.

To discover whether two weights be equal, we must oppose them to each other in a machine where they act in a similar manner, and then see if they maintain an equilibrium; for example, we fulfil this condition if we suspend them at the two extremities of a lever, supported at its centre, and whose arms are equal. Such is the general idea of a balance. The beam of a good balance ought to be a bar of well-tempered steel, of such form as to secure perfect inflexibility under any load which may be fitly applied to its extremities. Its arms should be quite equal in weight and length upon each side of its point of suspension; and this point should be placed in a vertical line over the centre of gravity; and the less distant it is from it, the more delicate will be the balance. Were it placed exactly in that centre, the beam would not spontaneously recover the horizontal position when it was once removed from it. To render its indications more readily commensurable, a slender rod or needle is fixed to it, at right angles, in the line passing through its centres of gravity and suspension. The point, or rather edge of suspension, is made of perfectly hard steel, and turns upon a bed of the same. For common uses the arms of a balance can be made sufficiently equal to give satisfactory results; but, for the more refined purposes of science, that equality should never be presumed nor trusted to; and, fortunately, exact weighing is quite independent of that equality. To weigh a body is to determine how many times the weight of that body contains another species of known weight, as of grains or pounds, for example. In order to find it out, let us place the substance, suppose a piece of gold, in the left hand scale of the balance; counterpoise it with sand or shot in the other, till the index needle be truly vertical, or stand in the middle of the scale, proving the beam to be horizontal. Now remove gently the piece of gold, and substitute in its place standard multiple weights of any graduation, English or French, till the needle again resumes the vertical position, or till its oscillations upon either side of the zero point are equal. These weights will represent precisely the weight of the gold, since they are placed in the same circumstances precisely with it, and make the same equilibrium with the weight laid in the other scale.

This method of weighing is obviously independent of the unequal length as well as the unequal weight of the arms of the beam. For its perfection two requisites only are indispensable. The first is that the points of suspension should be rigorously the same in the two operations; for the power of a given weight to turn the beam being unequal, according as we place it at different distances from the centre of suspension, did that point vary in the two consecutive weighings, we would require to employ, in the second, a different weight from that of the piece of gold, in order to form an equilibrium with the sand or shot originally put in the opposite scale; and as there is nothing to indicate such inequality in the states of the beam, great errors would result from it. The best mode of securing against such inequality is to suspend the cords of the scales from sharp-edged rings, upon knife edges, at the ends of the beam, both made of steel so

hard tempered as to be incapable of indentation. The second condition is, that the balance should be very sensible, that is, when in equilibrium and loaded, it may be disturbed, and its needle may oscillate, by the smallest weight put into either of the scales. This sensibility depends solely upon the centre or nail of suspension; and it will be the more perfect the less friction there is between that *knife-edge* surface and the plane which supports it. Both should therefore be as hard and highly polished as possible; and should not be suffered to press against each other, except at the time of weighing. Every delicate balance of moderate size, moreover, should be suspended within a glass case, to protect it from the agitations of the air, and the corroding influence of the weather. In some balances a ball is placed upon the index or needle (whether that index stand above or below the beam), which may be made to approach or recede from the beam by a fine-threaded screw, with the effect of varying the centre of gravity relatively to the point of suspension, and thereby increasing, at will, either the sensibility, or the stability of the balance. The greater the length of the arms, the less distant the centre of gravity is beneath the centre of suspension, the better polished its central knife-edge of 30°, the lighter the whole balance, and the less it is loaded; the greater will be its sensibility. In all cases the arms must be quite inflexible. A balance made by Ramsden for the Royal Society, is capable of weighing ten pounds, and turns with one hundredth of a grain, which is the seven-millionth part of the weight. In pointing out this balance to me one evening, Dr. Wollaston told me it was so delicate, that Mr. Pond, then astronomer royal, when making some observations with it, found its indications affected by his relative position before it, although it was enclosed in a glass case. When he stood opposite the right arm, that end of the beam preponderated, in consequence of its becoming expanded by the radiation of heat from his body; and when he stood opposite the left arm, he made this preponderate in its turn. It is probable that Mr. Pond had previously adjusted the centres of gravity and suspension so near to each other as to give the balance its maximum sensibility, consistent with stability. Were these centres made to coincide, the beam, when the weights are equal, would rest in any position, and the addition of the smallest weight would overset the balance, and place the beam in a vertical position, from which it would have no tendency to return. The sensibility in this case would be the greatest possible; but the other two requisites of level and stability would be entirely lost. The case would be even worse if the centre of gravity were higher than the centre of suspension, as the balance when deranged, if free, would make a revolution of no less than a semi-circle. A balance may be made by a fraudulent dealer to weigh falsely, though its arms be equal, provided the suspension be as low as the centre of gravity, for he has only to toss his tea, for instance, forcibly into one scale to cause 15 ounces of it, or thereby, to counterpoise a pound weight in the other. Inspectors of weights, &c. are not *au fait* to this fruitful source of fraud among hucksters.

BALSAMS (*Baumes*, Fr. *Balsame*, Germ.) are native compounds of ethereal or essential oils, with resin, and frequently benzoic acid. Most of them have the consistence of honey; but a few are solid, or become so by keeping. They flow either spontaneously, or by incisions made from trees and shrubs in tropical climates. They possess peculiar powerful smells, aromatic hot tastes, but lose their odoriferous properties by long exposure to the air. They are insoluble in water; soluble, to a considerable degree, in ether; and completely in alcohol. When distilled with water, ethereal oil comes over, and resin remains in the retort.

1. BALSAMS WITH BENZOIC ACID :—

Balsam of Peru is extracted from the *myroxylon peruiferum*, a tree which grows in Peru, Mexico, &c.; sometimes by incision, and sometimes by evaporating the decoction of the bark and branches of the tree. The former kind is very rare, and is imported in the husk of the cocoa-nut, whence it is called balsam *en coque*. It is brown, transparent only in thin layers, of the consistence of thick turpentine; an agreeable smell, an acrid and bitter taste; formed of two matters, the one liquid, the other granular, and somewhat crystalline. In 100 parts, it contains 12 of benzoic acid, 88 of resin, with traces of a volatile oil.

The second sort, the *black* balsam of Peru, is much more common than the preceding, translucent, of the consistence of well-boiled sirup, very deep red-brown color, an almost intolerably acrid and bitter taste, and a stronger smell than the other balsam. Stoltze regards it as formed of 69 parts of a peculiar oil, 20·7 of a resin, little soluble in alcohol, of 6·4 of benzoic acid, of 0·6 of extractive matter, and 0·9 of water.

From its high price, balsam of Peru is often adulterated with copaiba, oil of turpentine, and olive oil. One thousand parts of good balsam should, by its benzoic acid, saturate 75 parts of crystallized carbonate of soda. It is employed as a perfume for pomatums, tinctures, lozenges, sealing-wax, and for chocolate and *liqueurs*, instead of vanilla, when this happens to be very dear.

Liquid amber, Storax or Styrax, flows from the leaves and trunk of the *liquid amber styraciflua,* a tree which grows in Virginia, Louisiana, and Mexico. It is brownish ash-gray, of the consistence of turpentine, dries up readily, smells agreeably, like benzoin, has a bitterish, sharp, burning taste; is soluble in 4 parts of alcohol, and contains only 1·4 per cent. of benzoic acid.

Balsam of Tolu flows from the trunk of the *myroxylon toluiferum,* a tree which grows in South America; it is, when fresh, of the consistence of turpentine, is brownish-red, dries into a yellowish or reddish brittle resinous mass, of a smell like benzoin; is soluble in alcohol and ether; affords, with water, benzoic acid.

Chinese varnish flows from the bark of the *Augia sinensis;* it is a greenish yellow turpentine-like substance, smells aromatic, tastes strong and rather astringent, in thin layers dries soon into a smooth shining lac, and consists of resin, ethereous oil, and benzoic acid. It is soluble in alcohol and ether; and has been employed, immemorially, in China, for lackering and varnishing surfaces, either alone or colored.

BALSAMS WITHOUT BENZOIC ACID :—

Copaira balsam, balsam of copahu or capivi, is obtained from incisions made in the trunk of the *Copaifera officinalis,* a tree which grows in Brazil and Cayenne. It is pale yellow, middling liquid, clear transparent, has a bitter, sharp, hot taste; a penetrating disagreeable smell; a specific gravity of from 0·950 to 0·996. It dissolves in absolute alcohol, partially in spirit of wine, forms with alkalis, crystalline compounds. It consists of 45·59 ethereous oil, 52·75 of a yellow brittle resin, and 1·66 of a brown viscid resin. The oil contains no oxygen, has a composition like oil of turpentine, dissolves caoutchouc (according to Durand), but becomes oxydized in the air, into a peculiar species of resin. This balsam is used for making paper transparent, for certain lackers, and in medicine.

Mecca balsam, or opobalsam, is obtained both by incisions of, and by boiling, the branches and leaves of the *Balsamodendron Gileadense,* a shrub which grows in Arabia Felix, Lesser Asia, and Egypt. When fresh it is turbid, whitish, becomes, by degrees, transparent; yellow, thickish, and eventually solid. It smells peculiar, but agreeable; tastes bitter and spicy; does not dissolve completely in hot spirit of wine, and contains 10 per cent. of ethereous oil, of the specific gravity 0·876.

Japan lac varnish flows from incisions in the trunk of the *Rhus Vernix (Melanorrhea usitata)* which is cultivated in Japan, and grows wild in North America. The juice becomes black in the air; when purified, dissolves in very little oil; and, mixed with coloring matter, it constitutes the celebrated varnish of the Japanese.

For Benzoin and Turpentine. see these articles in their alphabetical places.

BANDANNA. A style of calico printing, in which white or brightly colored spots are produced upon a red or dark ground. It seems to have been practised from time immemorial in India, by binding up firmly with thread, those points of the cloth which were to remain white or yellow, while the rest of the surface was freely subjected to the dyeing operations.

The European imitations have now far surpassed, in the beauty and precision of the design, the oriental patterns; having called into action the refined resources of mechanical and chemical science. The general principles of producing bright figures upon dark grounds, are explained in the article CALICO-PRINTING; but the peculiarities of the Bandanna printing may be conveniently introduced here. In Brande's Journal for July, 1823, I described the Bandanna gallery of Messrs. Monteith at Glasgow, which, when in full action some years ago, might be reckoned the most magnificent and profitable printing apartment in the world. The white spots were produced by a solution of chlorine, made to percolate down through the Turkey red cotton cloth, in certain points defined and circumscribed by the pressure of hollow lead types in plates, in a hydraulic press. *Fig.* 96 is an elevation of one press; A, the top or entablature; B B, the checks or pillars; C, the upper block for fastening the upper lead perforated pattern to; D, the lower block to which the fellow pattern is affixed, and which moves up and down with the piston of the press; E, the piston or ram; F, the sole or base; G, the water-trough, for the discharged or spotted calico to fall into; H, the small cistern, for the aqueous chlorine or liquor-meter, with glass tubes for indicating the height of liquor inside of the cistern; *e e,* glass stopcocks, for admitting the liquor into that cistern from the general reservoir; *f f,* stopcocks for admitting water to wash out the chlorine; *g g,* the pattern lead-plates, with screws for setting the patterns parallel to each other; *m m,* projecting angular pieces at each corner, perforated with a half-inch hole to receive the four guide pins rising from the lower plate, which serve to secure accuracy of adjustment between the two faces of the lead pattern plates; A A, two rollers which seize and pull through the discharged pieces, and deliver them into the water-trough. To the left of D there is a stopcock for filling the trough with water; L, is the waste tube for chlorine liquor and water of washing. The contrivance for blowing a stream of air across the cloth, through the pattern tubes, is not represented in the figure.

Sixteen engines similar to the above, each possessing the power of pressing with several hundred tons, are arranged in one line, in subdivisions of four; the spaces

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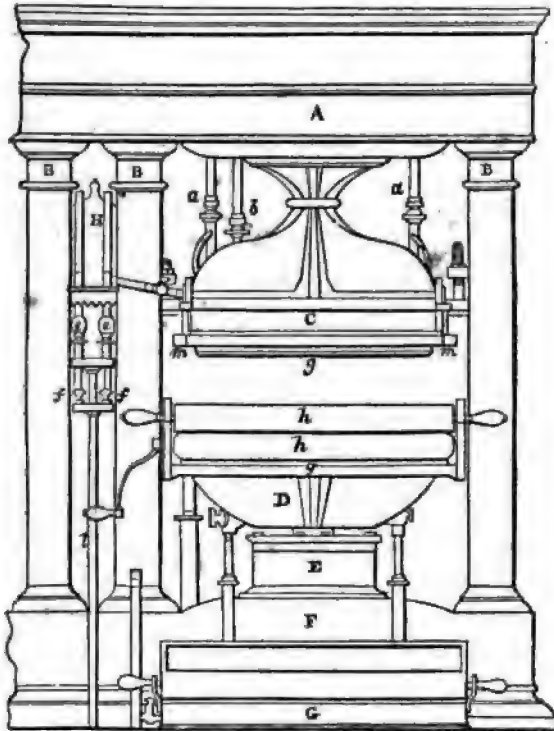
between each subdivision serving as passages to allow the workmen to go readily from the front to the back of the presses. Each occupies twenty-five feet, so that the total length of the apartment is 100 feet.

To each press is attached a pair of patterns in lead, (or plates, as they are called,) the manner of forming which will be described in the sequel. One of these plates is fixed to the upper block of the press. This block is so contrived, that it rests upon a kind of universal joint, which enables this plate to apply more exactly to the under fellow-plate. The latter sits on the moveable part of the press, commonly called the sill. When this is forced up, the two patterns close on each other very nicely, by means of the guide-pins at the corners, which are fitted with the utmost care.

The power which impels this great hydrostatic range is placed in a separate apartment, called the machinery room. This machinery consists of two press cylinders of a peculiar construction, having solid rams accurately fitted to them. To each of these cylinders, three little force-pumps, worked by a steam-engine, are connected.

The piston of the large cylinder is eight inches in diameter, and is loaded with a top-weight of five tons. This piston can be made to rise about two feet through a leather stuffing or collar. The other cylinder has a piston of only one inch in diameter, which is also loaded with a top-weight of five tons. It is capable, like the other, of being raised two feet through its collar.

Supposing the pistons to be at their lowest point, four of the six small force-pumps are put in action by the steam-engine, two of them to raise the large piston, and two the little one. In a short time, so much water is injected into the cylinders, that the loaded pistons have arrived at their highest points. They are now ready for working the hydrostatic discharge-presses, the water pressure being conveyed from the one apartment to the other, under ground, through strong copper tubes, of small calibre.

Two valves are attached to each press, one opening a communication between the large

driving-cylinder and the cylinder of the press, the other between the small driving-cylin—
der and the press. The function of the first is simply to lift the under-block of the press
into contact with the upper-block; that of the second, is to give the requisite compression
to the cloth. A third valve is attached to the press, for the purpose of discharging the
water from its cylinder, when the press is to be relaxed, in order to remove or draw
through the cloth.

From twelve to fourteen pieces of cloth, previously dyed Turkey-red, are stretched
over each other, as parallel as possible, by a particular machine. These parallel layers are
then rolled round a wooden cylinder, called by the workmen, a drum. This cylinder is
now placed in its proper situation at the back of the press. A portion of the fourteen lay—
ers of cloth, equal to the area of the plates, is next drawn through between them, by hooks
attached to the two corners of the webs. On opening the valve connected with the eight—
inch driving-cylinder, the water enters the cylinder of the press, and instantly lifts its lower
block, so as to apply the under plate with its cloth, close to the upper one. This valve is
then shut, and the other is opened. The pressure of five tons in the one inch prime-cylin—
der, is now brought to bear on the piston of the press, which is eight inches in diameter.
The effective force here will, therefore, be 5 tons $\times 8^2 = 320$ tons; the areas of cylinders
being to each other, as the squares of their respective diameters. The cloth is thus con-
densed between the leaden pattern-plates with a pressure of 320 tons, in a couple of
seconds ;—a splendid example of automatic art.

The next step, is to admit the blanching or discharging liquor (aqueous chlorine, ob-
tained by adding sulphuric acid to solution of chloride of lime) to the cloth. This liquor
is contained in a large cistern, in an adjoining house, from which it is run at pleasure into
small lead cisterns H attached to the presses; which cisterns have graduated index tubes,
for regulating the quantity of liquor according to the pattern of discharge. The stopcocks
on the pipes and cisterns containing this liquor, are all made of glass.

From the measure-cistern H, the liquor is allowed to flow into the hollows in the upper
lead-plate, whence it descends on the cloth, and percolates through it, extracting in its pas-
sage the Turkey-red dye. The liquor is finally conveyed into the waste pipe, from a groove
in the under block. As soon as the chlorine liquor has passed through, water is admit-
ted in a similar manner, to wash away the chlorine; otherwise, upon relaxing the pres-
sure, the outline of the figure discharged would become ragged. The passage of the dis-
charge liquor, as well as of the water through the cloth, is occasionally aided by a pneu-
matic apparatus, or blowing machine; consisting of a large gasometer, from which air
subjected to a moderate pressure may be allowed to issue, and act in the direction of the
liquid upon the folds of the cloth. By an occasional twist of the air stopcock, the work-
man also can ensure the equal distribution of the discharging liquor, over the whole ex-
cavations in the upper plate. When the demand for goods is very brisk, the air appara-
tus is much employed, as it enables the workman to double his product.

The time requisite for completing the discharging process in the first press is suffi-
cient to enable the other three workmen to put the remaining fifteen presses in play. The
discharger proceeds now from press to press, admits the liquor, the air, and the water;
and is followed at a proper interval by the assistants, who relax the press, move forwards
another square of the cloth, and then restore the pressure. Whenever the sixteenth press
has been liquored, &c., it is time to open the first press. In this routine, about ten min-
utes are employed; that is, 224 handkerchiefs (16+14) are discharged every ten minutes.
The whole cloth is drawn successively forward, to be successively treated in the above
method.

When the cloth escapes from the press, it is passed between the two rollers in front; from
which it falls into a trough of water placed below. It is finally carried off to the wash-
ing and bleaching department, where the lustre of both the white and the red is con-
siderably brightened.

By the above arrangement of presses, 1600 pieces, consisting of 12 yards each=19,200
yards, are converted into Bandannas in the space of ten hours, by the labor of four
workmen.

The patterns, or plates, which are put into the presses to determine the white figures
on the cloth, are made of lead in the following way. A trellis frame of cast-iron, one
inch thick, with turned-up edges, forming a trough rather larger than the intended lead
pattern, is used as the solid ground-work. Into this trough, a lead plate about one half
inch thick, is firmly fixed by screw nails passing up from below. To the edges of this lead
plate, the borders of the piece of sheet-lead are soldered, which covers the whole outer
surface of the iron frame. Thus a strong trough is formed, one inch deep. The upright
border gives at once great strength to the plate, and serves to confine the liquor. A thin
sheet of lead is now laid on the thick lead-plate, in the manner of a veneer on toilet-
tables, and is soldered to it round the edges. Both sheets must be made very smooth
beforehand, by hammering them on a smooth stone table, and then finishing with a plane :
the surface of the thin sheet (now attached) is to be covered with drawing paper, pasted

on, and upon this the pattern is drawn. It is now ready for the cutter. The first thing which he does, is to fix down with brass pins all the parts of the pattern which are to be left solid. He now proceeds with the little tools generally used by block-cutters, which are fitted to the different curvatures of the pattern, and he cuts perpendicularly quite through the thin sheet. The pieces thus detached are easily lifted out; and thus the channels are formed which design the white figures on the red cloth. At the bottom of the channels, a sufficient number of small perforations are made through the thicker sheet of lead, so that the discharging liquor may have free ingress and egress. Thus one plate is finished; from which, an impression is to be taken by means of printers' ink, on the paper pasted upon another plate. The impression is taken in the hydrostatic press. Each pair of plates constitutes a set, which may be put into the presses, and removed at pleasure.

BARBERRY. The root of this plant contains a yellow coloring matter, which is soluble in water and alcohol, and is rendered brown by alkalis. The solution is employed in the manufacture of Morocco leather.

BARILLA. A crude soda, procured by the incineration of the *salsola soda*, a plant cultivated for this purpose in Spain, Sicily, Sardinia, &c. Good barilla usually contains, according to my analysis, 20 per cent. of real alkali, associated with muriates and sulphates, chiefly of soda, some lime, and alumina, with very little sulphur. Caustic leys made from it, are used in the finishing process of the hard soap manufacture. 125,068 cwts. were imported in 1835, of which only 5·807 were exported. The duty is 2*s*. per cwt. Of the above quantity, 64,174 came from Spain and the Balearic islands, 39,943 from the Canaries, and 20,432 from Italy and the Italian islands.

BARIUM, the metallic basis of Baryta.

BARK OF OAK, for tanning. Unfortunately, the Tables of Revenue published by the Board of Trade, mix up this bark and the dyeing barks together, and give the sum of the whole for 1835, at 826,566 cwts., of which only 2,264 were re-exported. The duty is 1*d*. per cwt. from British possessions, and 8*d*. from other parts.

BARLEY (*Orge*, Fr.; *Gerste*, Germ.) English barley is that with two-rowed ears, or the *hordeum vulgare distichon* of the botanists; the Scotch beer or bigg, is the *hordeum vulgare hexastichon*. The latter has two rows of ears, but 3 corns come from the same point, so that it seems to be six-eared. The grains of bigg are smaller than those of barley, and the husks thinner. The specific gravity of English barley varies from 1·25 to 1·33; of bigg from 1·227 to 1·265; the weight of the husk of barley is $\frac{1}{5}$, that of bigg $\frac{2}{7}$. 1000 parts of barley flour contain, according to Einhof, 720 of starch, 56 sugar, 50 mucilage, 36·6 gluten, 12·3 vegetable albumen, 100 water, 2·5 phosphate of lime, 68 fibrous or ligneous matter. Sp. gravity of barley is 1·235 by my trials.

BARM. The yeasty top of fermenting beer. See BEER, DISTILLATION, FERMENTATION.

BARYTA or BARYTES, one of the simple earths. It may be obtained most easily by dissolving the native carbonate of barytes (Witherite) in nitric acid, evaporating the neutral nitrate till crystals be formed, draining and then calcining these in a covered platina crucible, at a bright red heat. A less pure baryta may be obtained by igniting strongly a mixture of the carbonate and charcoal, both in fine powder and moistened. It is a grayish white earthy looking substance, fusible only at the jet of the oxy-hydrogen blowpipe, has a sharp caustic taste, corrodes the tongue and all animal matter, is poisonous even in small quantities, has a very powerful alkaline reaction; a specific gravity of 4·0; becomes hot, and slakes violently when sprinkled with water, falling into a fine white powder, called the hydrate of baryta, which contains 10½ per cent. of water, and dissolves in 10 parts of boiling water. This solution lets fall abundant columnar crystals of hydrate of baryta as it cools; but it still retains one twentieth its weight of baryta, and is called baryta water. The above crystals contain 61 per cent. of water, of which, by drying, they lose 50 parts. This hydrate may be fused at a red heat without losing any more water. Of all the bases, baryta has the strongest affinity for sulphuric acid, and is hence employed either in the state of the above water, or in that of one of its neutral salts, as the nitrate or muriate, to detect the presence, and determine the quantity of that acid present in any soluble compound. Its prime equivalent, according to Berzelius, is 956,880, oxygen being 100; or 76,676, hydrogen being 1,000. Native sulphate of baryta, or heavy spar, is fraudulently used to adulterate white lead by the English dealers to a shameful extent.

BASSORINE. A constituent part of a species of gum which comes from Bassora, as also of gum tragacanth, and of some gum resins. It is semi-transparent, difficult to pulverize, swells considerably in cold or boiling water, and forms a thick mucilage without dissolving. Treated with ten times its weight of nitric acid, it affords nearly 20 per cent. of its weight of mucic acid, being much more than is obtainable from gum arabic or cherry-tree gum. Bassorine is very soluble in water slightly acidulated with

ic or muriatic acid. This principle is procured by soaking gum Bassora in a grea▩▩▩▩
antity of cold water, and in removing, by a filter, all the soluble parts.

BATHS. (*Bains,* Fr. *Baden,* Germ.) Warm baths have lately come into ver▩▩▩
neral use, and they are justly considered as indispensably necessary in all moder▩▩▩
uses of any magnitude, as also in club-houses, hotels, and hospitals. But the mod▩▩▩
constructing these baths, and of obtaining the necessary supplies of hot and cold w▩▩▩
:r, does not appear to have undergone an improvement equal to the extension of the▩▩▩
mployment.

The several points in regard to warm baths, are,

1. The materials of which they are constructed.
2. The r situation.
3. The supply of cold water.
4. The supply of hot water.
5. Minor comforts and conveniences.

1. As to the materials of which they are constructed. Of these the best ar▩▩
slabs of polished marble, properly bedded with good water-tight cement, in a season▩▩
wooden case, and neatly and carefully united at their respective edges. These, when
originally well constructed, form a durable, pleasant, and agreeable-looking bath; but
the expense is often objectionable, and, in upper chambers, the weight may prove
inconvenient. If of white or veined marble, they are also apt to get yellow or dis-
colored by frequent use, and cannot easily be cleansed; so that large Dutch tiles, as
they are called, or square pieces of white earthenware, are sometimes substituted;
which, however, are difficultly kept water-tight; so that, upon the whole, marble is
preferable.

Where there are reasons for excluding marble, copper or tinned iron plate is the usual
material resorted to. The former is most expensive in the outfit, but far more durable
than the latter, which is, moreover, liable to leakage at the joints, unless most carefully
made. Either the one or the other should be well covered, outside and inside, with seve-
ral coats of paint, which may then be marbled or otherwise ornamented.

Wooden tubs, square or oblong, and oval, are sometimes used for warm baths; and
are cheap and convenient, but neither elegant nor cleanly. The wood always contracts
a mouldy smell; and the difficulty and nuisance of keeping them water-tight, and
preventing shrinkage, are such as to exclude them from all except extemporaneous ap-
plication.

2. As to the situation of the bath, or the part of the house in which it is to be
placed.—In hotels, and club-houses, this is a question easily determined: several baths
are usually here required, and each should have annexed to it a properly warmed
dressing-room. Whether they are up stairs or down stairs, is a question of convenience,
but the basement story, in which they are sometimes placed, should always be avoided;
there is a coldness and dampness belonging to it, in almost all weathers, which is neither
agreeable nor salubrious.

In hospitals, there should be at least two or three baths on each side of the house (the
men's and women's), and the supply of hot water should be ready at a moment's notice.
The rooms in which the baths are placed should be light, and comparatively large and
airy; and such conveniences for getting into and out of the bath should be adopted, as
the sick are well known to require. The dimensions of these baths should also be larger
than usual.

In private houses, the fittest places for warm baths are dressing-rooms annexed to
the principal bed-rooms; or, where such convenience cannot be obtained, a separate
bath-room, connected with the dressing-room, and always upon the bed-room floor. All
newly-built houses should be properly arranged for this purpose, and due attention
should be paid to the warming of the bath-room, which ought also to be properly ven-
tilated. A temperature of 70° may easily be kept up in it, and sufficient ventilation
is absolutely requisite, to prevent the deposition of moisture upon the walls and
furniture.

The objection which formerly prevailed, in respect to the difficulty of obtaining
adequate supplies of water, in the upper rooms, has been entirely obviated, by having
cisterns at or near the top of the house; and we would just hint that these should be
so contrived, as to be placed out of the reach of frost; a provision of the utmost im-
portance in every point of view, and very easily effected in a newly-built house, though
it unfortunately happens, that architects usually regard these matters as trifles, and
treat them with neglect, as indeed they do the warming and ventilation of buildings
generally.

3. The supply of water of proper quality and quantity, is a very important point,
as connected with the present subject. The water should be soft, clean, and pure; and
as free as possible from all substances mechanically suspended in it. In many cases,
it answers to dig a well for the exclusive supply of a large house with water. In most

parts of London this may effectually be accomplished, at a comparatively moderate expense; and, if the well be deep enough, the water will be abundant, soft, and pellucid. The labor of forcing it by a pump to the top of the house, is the only drawback: this, however, is very easily done by a horse-engine, or there are people enough about town, glad to undertake it at a shilling a day. I am led to these remarks by observing the filthy state of the water usually supplied, at very extravagant rates, by the water companies. It often partakes more of the appearance of pea-soup than of the pure element; fills our cisterns and pipes with mud and dirt, and, even when cleared by subsidence, is extremely unpalatable. It deposites its nastiness in the pipes connected with warm baths, and throws down a slippery deposite upon the bottom of the vessel itself to such an extent, as often to preclude its being used. at least as a luxury, which a clear and clean bath really is. This inconvenience may, in some measure, be avoided, by suffering the water to throw down its extraneous matters upon the bottom of the cistern, and drawing our supplies from pipes a little above it; there will, however, always be more or less deposite in the pipes themselves; and every time the water runs into the cistern, the grouts are stirred up, and diffused through its mass: this, from some cause or other, has lately become an intolerable nuisance; and he who reflects upon the miscellaneous contents of Thames water, will not have his appetite sharpened by a draught of the Grand Junction beverage, nor feel reanimated and refreshed by bathing in a compound so heterogeneous and unsavory.

4 and 5. In public bathing establishments, where numerous and constant baths are required, the simplest and most effective means of obtaining hot water for their supply consists in drawing it directly into the baths from a large boiler, placed somewhere above their level. This boiler should be supplied with proper feeding-pipes and gauges; and, above all things, its dimensions should be ample; it should be of wrought iron or copper, except where sea. water is used, in which case the latter metal is sometimes objectionable. The hot water should enter the bath by a pipe at least an inch and a half in diameter; and the cold water by one of the same dimension, or somewhat larger, so that the bath may not be long in filling. The relative proportions of the hot and cold water are, of course, to be adjusted by a thermometer, and every bath should have a two inch waste-pipe, opening about two inches from the top of the bath, and suffering the excess of water freely to run off; so that when a person is immersed in the bath, or when the supplies of water are accidentally left open, there may be no danger of an overflow.

Where there is a laundry in the upper story of the house, or other convenient place for erecting a copper and its appurtenances, a plan similar to the above may often be conveniently adopted in private houses, for the supply of a bath upon the principal bed-room floor. An attempt is sometimes made to place boilers behind the fires of dressing-rooms, or otherwise to erect them in the room itself, for the purpose of supplying warm water; but this plan is always objectionable, from the complexity of the means by which the supply of water is furnished to the boiler, and often dangerous from the flues becoming choaked with soot, and taking fire. Steam is also apt, in such cases, to escape in quantities into the room; so that it becomes necessary to search for other methods of heating the bath; one or two of the least objectionable of which I shall describe.

1. A contrivance of some ingenuity consists in suffering the water for the supply of the bath to flow from a cistern above it, through a leaden pipe of about one inch diameter, which is conducted into the kitchen or other convenient place, where a large boiler for the supply of hot water is required. The bath-pipe is immersed in this boiler, in which it makes many convolutions, and, again emerging, ascends to the bath. The operation is simply this:—the cold water passing through the convolutions of that part of the pipe which is immersed in the boiling water, receives there sufficient heat for the purpose required, and is delivered in that state by the ascending pipe into the bath, which is also supplied with cold water and waste-pipes as usual. The pipe may be of lead, as far as the descending and ascending parts are concerned, but the portion forming the worm, or convolutions immersed in the boiler, should be copper, in order that the water within it may receive heat without impediment.

This plan is economical only where a large boiler is constantly kept at work in the lower part of the house; otherwise, the trouble and expense of heating such a boiler, for the mere purpose of the bath, render it unavailable. The worm-pipe is also apt to become furred, upon the outside, by the deposition of the earthy impurities of the water in which it is immersed; it then becomes a bad conductor of heat, is cleansed with difficulty, and the plan is rendered ineffective. This system, however, has been adopted, in some particular cases, with satisfaction.

2. A much more simple, economical, and independent mode of heating a warm bath, by a fire placed at a distance from it, is the following, which is found to answer perfectly in private houses, as well as upon a more extended scale in large establish-

ments. It is certainly open to some objections, but these are overbalanced by its advantages. A wagon-shaped boiler, holding about six gallons of water, is properly placed over a small furnace, in any convenient and safe part of the house, as the kitchen, scullery, servants' hall, or wash-house. The bath itself, of the usual dimensions and construction, is placed where it is wanted, with a due supply of cold water from above. Two pipes issue from within an inch of the bottom of the bath at its opposite extremities; one at the head of the bath, about one inch, and the other at the foot, an inch and one eighth in diameter. These tubes descend to the boiler, the smaller one entering it at the bottom, and the larger one issuing from its top.

Under these circumstances, supposing the pipes and boiler everywhere perfectly tight, when the bath is filled, the water will descend into and expel the air from the boiler, and completely fill it. Now, upon making a gentle fire under the boiler, an ascending current of warm water will necessarily pass upwards through the larger pipe which issues from its top, and cold water will descend by the pipe which enters at the bottom; and thus, by the establishment of currents, the whole mass of water in the bath will become heated to the desired point; or, if above it, the temperature may easily be lowered by the admixture of cold water.

The advantages of this form of bath are numerous. The shorter the pipes of communication the better, but they may extend forty or fifty feet without any inconvenience beyond that of expense; so that there is no obstacle to the bath being near the bed-room while the boiler is on the basement story. There is but little time required for heating the bath; the water in which may, if requisite, be raised to about 100° in about half an hour from the time of lighting the fire. The consumption of fuel is also trifling.

The following are the chief disadvantages attendant upon this plan, and the means of obviating them :—

It is necessary, when the water has acquired its proper temperature, to withdraw the fire from the boiler, or not to use the bath immediately, as it may go on acquiring some heat from the boiler, so that we may become inconveniently hot in the bath. When, therefore, this bath is used, we may proceed as follows :—heat the water in it an hour before it is wanted, to about 100°, and then extinguish the fire. The water will retain its temperature, or nearly so, for three or four hours, especially if the bath be shut up with a cover; so that when about to use it, cold water may be admitted till the temperature is lowered to the required point, and thus all the above inconveniences are avoided.

Another disadvantage of this bath arises from too fierce a fire being made under the boiler, so as to occasion the water to boil within it, a circumstance which ought always to be carefully avoided. In that case, the steam rising in the upper part of the boiler, and into the top pipe, condenses there, and occasions violent concussions, the noise of which often alarms the whole house, and leads to apprehensions of explosion, which, however, is very unlikely to occur; but the concussions thus produced injure the pipes, and may render them leaky; so that in regard to these, and all other baths, &c., we may remark, that the pipes should pass up and down in such parts of the house as will not be injured if some leakage takes place; and under the bath itself should be a sufficiently large leaden tray with a waste-pipe, to receive and carry off any accidental drippings, which might injure the ceilings of the rooms below. In all newly-built houses, two or three flues should be left in proper places for the passage of ascending and descending water-pipes; and these flues should in some way receive at their lower part a little warm air in winter, to prevent the pipes freezing; the same attention should also be paid to the situation of the cisterns of water in houses, which should be kept within the house, and always supplied with a very ample waste-pipe, to prevent the danger of overflow. Cisterns thus properly placed, and carefully constructed, should be supplied from the water-mains by pipes kept under ground, till they enter the house, and not carried across the area, or immediately under the pavement, where they are liable to freeze.

3. Baths are sometimes heated by steam, which has several advantages: it may either be condensed directly into the water of the bath, or, if the bath be of copper or tinned iron, it may be conducted into a casing upon its outside, usually called a jacket; in the latter case there must be a proper vent for the condensed water, and for the escape of air and waste steam. Steam is also sometimes passed through a serpentine pipe, placed at the bottom of the bath. But none of these methods are to be recommended for adoption in private houses, and are only advisable in hospitals, or establishments where steam boilers are worked for other purposes than the mere heating of baths.

Many copper and tin baths have been lately constructed in London, with a little furnace attached to one end, and surrounded with a case or jacket, into which the water flows and circulates backwards and forwards till the whole mass in the bath gets heated to the due degree. One of the best of these is that constructed by Mr. Benham,

of Wigmore street. The bath must be placed near the fire-grate, and the smoke-pipe of the attached furnace be conducted up the chimney a certain way to secure a sufficient draught to maintain combustion. The above bath, well managed, heats the water from 50° to 98° in about 20 or 25 minutes, as I have experimentally proved. When the proper temperature is attained, the fire must of course be extinguished.

BDELLIUM. A gum resin, produced by an unknown plant which grows in Persia and Arabia. It comes to us in yellowish or reddish pieces, smells faintly, like myrrh, and consists of 59 resin, 9·2 gum, 30·6 bassorine, and 1·2 ethereous oil.

BEER. (*Bière*, Fr.; *Bier*, Germ.) The fermented infusion of malted barley, flavored with hops, constitutes the best species of beer; but there are many beverages of inferior quality to which this name is given, such as spruce beer, ginger beer, molasses beer, &c.; all of which consist of a saccharine liquor, partially advanced into the vinous fermentation, and flavored with peculiar substances.

The ancients were acquainted with beer, and the Romans gave it the appropriate name of *Cerevisia* (quasi *Ceresia*), as being the product of corn, the gift of Ceres. The most celebrated liquor of this kind in the old time, was the *Pelusian* potation, so called from the town where it was prepared at the mouth of the Nile. Aristotle speaks of the intoxication caused by beer; and Theophrastus very justly denominated it the *wine of barley*. We may, indeed, infer from the notices found in historians, that drinks analogous to our beer were in use among the ancient Gauls, Germans, and in fact almost every people of our temperate zone; and they are still the universal beverage in every land where the vine is not an object of rustic husbandry.

The manufacture of beer, or the art of brewing, may be conveniently considered under five heads :—

1. An examination of the natural productions which enter into its composition; or of barley and hops.

2. The changes which barley must undergo to fit it for making beer; or the processes of malting and mashing.

3. The formation of a proper wort from the mashed malt and hops.

4. The fermentation of that wort; and,

5. The fining, ripening, and preservation of the beer.

I. *Of the materials.*

1. Barley, wheat, maize, and several other kinds of corn are capable of undergoing those fermentative changes, by which beer may be made; but the first substance is by far the fittest. There are two species of barley, the *hordeum vulgare* or common barley, having two seeds arranged in a row on its spikes; and the *hordeum hexastichon*, in which three seeds spring from one point, so that its double row has apparently six seeds. The former is the proper barley, and is much the larger sized grain; the latter is little known in England, but is much cultivated in Scotland under the name of *bear* or *bigg*; being a hardy plant adapted to a colder country. The finer the climate in which barley grows, the denser and larger its seed, and the thinner its husk; thus the Norfolk and Suffolk barley is distinguished in these respects from that of Aberdeenshire. Bigg is a less compact grain than barley; the weight of a Winchester bushel (2150·42 cubic inches) of the former is only about 47 lbs., while that of a bushel of the latter is nearly 51 lbs. Their constituents, however, bear much the same proportion to each other.

The quality of barley is proved not only by its density when dry, but by the increase of volume which it acquires when steeped in water. Thus,

100 measures of average English barley thereby swell into								124.
100	—	of —	Scotch ditto,	-	-	-		121.
100	—	of —	— bigg or bear,			-		118.
Nay, 100 of very fine Suffolk barley have swollen into						-		183.
While 100 of an inferior Scotch bigg became no more than						-		109.

This circumstance indicates so nearly the probable yield of malt, that it is carefully attended to by the officers of excise, who gauge the steep cistern, and levy their duty in conformity with the largest volume. 100 pounds of good barley become almost one half heavier by the absorption of moisture; and weigh upon an average 147 pounds; the best of course taking up most water.

By chemical analysis barley flour seems to consist of 67·18 parts of hordeine, or starch and gluten intimately combined, 7·29 of vegetable fibre, 1·15 of coagulated albumen, 3·52 parts of gluten, 5·21 of sugar, 4·62 of gum, 0·24 of phosphate of lime, and 9·37 of water. The loss amounted to 1·42. To these principles should be added a peculiar volatile oil of a concrete nature, which is obtained during the process of distilling fermented malt wash. (See WHISKEY.) It may also be extracted from barley flour, by the direct action of alcohol; and never amounts to more than a few parts in the thousand. The husk also contains some of that fetid oil. Proust thought that he had discovered in barley a peculiar principle, to which he gave the name of *hordeine*; and which he separated from starch by the action of both cold and boiling water. He found that by treat-

ing barley meal successively with water, he obtained from 89 to 90 parts of a farinaceou: substance, composed of from 32 to 33 of starch, and from 57 to 58 of *hordeine*. Einhof obtained from barley seeds, 70·05 of flour, 18·75 of husks or bran, and 11·20 of water.

According to Proust, hordeine is a yellowish powder, not unlike fine saw-dust. contains no azote, for it affords no ammonia by distillation, and is therefore very dissimilar to gluten. In the germination of barley, which constitutes the process of malting, the proportion of hordeine is greatly diminished by its conversion into sugar and starch. Other chemists suppose that the *hordeine* of Proust is merely a mixture of the bran and the barley with starch and gluten. It is obvious that the subject stands in need of new chemical researches. In barley the husk constitutes from one fourth to one fifth of the whole weight; in oats it constitutes one third; and in wheat one tenth. From the analysis of barley flour recently made, it appears to consist in 1000 parts : of water, 100; albumen, 22·3; sugar, 50; gum or mucilage, 50; gluten, 37·6; starch, 720; phosphate of lime, 2·5.

2. The hop, *humulus lupulus*, the female flowers of the plant. Ives first directed attention to a yellow pulverulent substance which invests the scales of the catkins, amounting to about one eighth of their weight; and referred to it the valuable properties which hops impart to beer. We may obtain this substance by drying the hops at a temperature of 86° F., introducing them into a coarse canvass bag, and shaking it so that the yellow powder shall pass through the pores of the canvass. This powder bears some resemblance to lycopodium. Of the 13 parts in 100 of this powder, 4 parts are foreign matters, derived from the scales of the cones; leaving 9 parts of a peculiar granular substance. When distilled with water, this substance affords two per cent. of its weight ($\frac{2}{10}$ for 100 times the weight of hops) of a volatile colorless oil, to which the plant owes its peculiar aroma. This oil dissolves in water in considerable quantity. It appears to contain sulphur (for it blackens solutions of silver), and also acetate of ammonia. No less than 65 per cent. of the yellow dust is soluble in alcohol. This solution, treated with water and distilled, leaves a resin, which amounts to 52·5 per cent. It has no bitter taste, and is soluble in alcohol and ether. The watery solution from which the resin was separated contains the bitter substance which has been called *lupuline* by Payen and Chevallier, mixed with a little tannin and malic acid. To obtain this in a state of purity, the free acid must be saturated with lime, the solution evaporated to dryness, and the residuum must be treated with ether, which removes a little resin; after which the *lupuline* is dissolved out by alcohol, which leaves the malate of lime. On evaporating away the alcohol, the lupuline remains, weighing from 8·3 to 12·5 per cent. It is sometimes white, or slightly yellowish, and opaque, sometimes orange yellow and transparent. At ordinary temperatures it is inodorous, but when heated strongly it emits the smell of hops. It possesses the characteristic taste and bitterness of the hop. Water dissolves it only in the proportion of 5 per cent., but it thereby acquires a pale yellow color. Lupuline is neither acid nor alkaline; it is acted upon neither by the dilute acids nor alkalis, nor by the solutions of the metallic salts; it is quite soluble in alcohol, but hardly in ether. It contains apparently no azote, for it affords no ammonia by destructive distillation; but only an empyreumatic oil.

The yellow dust of hops contains, moreover, traces of a fatty matter, gum, a small quantity of an azotized substance, and several saline combinations in minute quantity. Boiling water dissolves from 19 to 31 per cent. of the contents of the dust, of which a large proportion is resin. Ives thought that the scales of the catkins of hops, when freed from the yellow powder, contained no principles analogous to it; but Payen and Chevallier have proved the contrary. The cones of hop give up to boiling alcohol 3 per cent. of soluble matter; while the same cones, stripped of their yellow powder, yield only 26 per cent.; and further, these chemists found the same principles in the different parts of the hop, but in different proportions.

The packing of the hop catkins or cones is one of the most important operations towards the preservation of this plant; and is probably the cause of the enormous difference in value between the English and French hops after a few years keeping. The former, at the end of six years, possess still great value, and may be sold as an article only two or three years old; while the latter have lost the greater part of their value in three years, and are no more saleable at the end of four. In France, it is packed merely by tramping it with the feet in sacks. Under this slight pressure, large interstitial spaces are left amid the mass of the hops, through which the air freely circulates, carrying off the essential oil, and oxygenating some of the other proximate principles, so as to render them inert. By the English method, on the contrary, the hops, after being well rammed into strong sacks hung in frames, are next subjected to the action of a hydraulic press. The valuable yellow powder thus enclosed on every side by innumerable compact scales, is completely screened from the contact of the atmosphere, and from all its vicissitudes of humidity. Its essential oil, in particular, the basis of its flavour, is preserved without decay.

According to the experiments of *Chevallier* and *Payen* upon the hops of England, Flanders, the Netherlands, and the department of the Vosges, those of the county of Kent afforded the largest cones, and were most productive in useful secreted and soluble matters. Next to them were the hops of Alost.

The best hops have a golden yellow color, large cones, an agreeable aroma : when rubbed between the hands, they leave yellow traces, powerfully odoriferous, without any broken portions of the plant, such as leaves, stems, and scaly fragments. When alcohol is digested on good hops, from 9 to 12 per cent. of soluble yellow matter may be obtained by evaporating it to dryness. This is a good test of their quality.

The best-flavored and palest hops are packed in sacks of fine canvass, which are called pockets, and weigh about 1½ cwt. each. These are bought by the ale brewers. The stronger-flavored and darker-colored hops are packed in bags of a very coarse texture like door-mats, called hop bags : these contain generally about 3 cwt., and are sold to the porter and beer brewers. After the end of a year or two, hops are reckoned to have lost much of their marketable value, and are then sold to the second-rate porter brewers, under the name of old hops. The finest hops are grown in the neighborhood of Canterbury; but those of Worcester have an agreeable mildness of flavor, greatly admired by many ale drinkers. When the bitter and aromatic principles disappear, the hops are no better than so much chaff; therefore, an accurate chemical criterion of their principles would be a great benefit to the brewer.

II. *Malting.*—This process consists of three successive operations; the steeping; the couching, sweating, and flooring; and the kiln-drying.

The *steeping* is performed in large cisterns made of wood or stone, which being filled with clear water up to a certain height, a quantity of barley is shot into them, and well stirred about with rakes. The good grain is heavy, and subsides; the lighter grains, which float on the surface, are damaged, and should be skimmed off; for they would injure the quality of the malt, and the flavor of the beer made with it. They seldom amount to more than two per cent. More barley is successively emptied into the steep cistern, till the water stands only a few inches, about five, above its surface; when this is levelled very carefully, and every light seed is removed. The steep lasts from forty to sixty hours, according to circumstances; new barley requiring a longer period than old, and bigg requiring much less time than barley.

During this steep, some carbonic acid is evolved from the grains, and combines with the water, which, at the same time, acquires a yellowish tinge, and a strawy smell, from dissolving some of the extractive matter of the barley husks. The grain imbibes about one half its weight of water, and increases in size by about one fifth. By losing this extract, the husk becomes about one seventieth lighter in weight, and paler in color.

The duration of the steep depends, in some measure, upon the temperature of the air, and is shorter in summer than in winter. In general from 40 to 48 hours will be found sufficient for sound dry grain. Steeping has for its object to expand the farina of the barley with humidity, and thus prepare the seed for germination, in the same way as the moisture of the earth prepares for the growth of the radicle and plumula in seed sown in it. Too long continuance in the steep is injurious; because it prevents the germination at the proper time, and thereby exhausts a portion of the vegetative power : it causes also an abstraction of saccharine matter by the water. The maceration is known to be complete when the grain may be easily transfixed with a needle, and is swollen to its full size. The following is reckoned a good test :—If a barley-corn, when pressed between the thumb and fingers, continues entire in its husk, it is not sufficiently steeped; but if it sheds its flour upon the fingers, it is ready. When the substance exudes in the form of a milky juice, the steep has been too long continued, and the barley is spoiled for germination.

In warm weather it sometimes happens that the water becomes acescent before the grain is thoroughly swelled. This accident, which is manifest to the taste and smell, must be immediately obviated by drawing off the foul water through the tap at the bottom of the cistern, and replacing it with fresh cold water. It does no harm to renew it two or three times at one steep.

The *couch.*—The water being drawn off, and occasionally a fresh quantity passed through, to wash away any slimy matter which may have been generated in warm weather, the barley is now laid upon the couch floor of stone flags, in square heaps from 12 to 16 inches high, and left in that position for 24 hours. At this period, the bulk of the grain being the greatest, it may be gauged by the revenue officers if they think fit. The moisture now leaves the surface of the barley so completely, that it imparts no dampness to the hand. By degrees, however, it becomes warm; the temperature rising 10° above the atmosphere, while an agreeable fruity smell is evolved. At this time, if the hand be thrust into the heap, it not only feels warm, but it gets bedewed with moisture. At this sweating stage, the germination begins; the fibrils of the radicle first sprout forth from the tip of every grain, and a white elevation appears, that soon

separates into three or more radicles, which grow rapidly larger. About a day after this appearance, the plumula peeps forth at the same point, proceeding thence beneath the husk to the other end of the seed, in the form of a green leaflet.

The greatest heat of the couch is usually about 96 hours after the barley has been taken out of the steep. In consequence, the radicles tend to increase in length with very great rapidity, and must be checked by artificial means, which constitute the chief art of the maltster. He now begins to spread the barley thinner on the floor, and turns it over several times in the course of a day, bringing the portions of the interior into the exterior surface. The depth, which was originally 15 or 16 inches is lowered a little at every turning over, till it be brought eventually down to three or four inches. Two turnings a day are generally required. At this period of spreading or flooring, the temperature in England is about 62°, and in Scotland 5 or 6 degrees lower.

About a day after the radicles appear, the rudiments of the stem, or of the plumula sprout forth, called by the English maltsters the *acrospire*. It issues from the same end of the seed as the radicle, but turns round, and proceeds within the husk towards the other end, and would there come forth as a green leaf, were its progress not arrested. The malting, however, is complete before the acrospire becomes a leaf.

The barley couch absorbs oxygen and emits carbonic acid, just as animals do in breathing, but to a very limited extent; for the grain loses only three per cent. of its weight upon the malt floor, and a part of this loss is due to waste particles. As the acrospire creeps along the surface of the seed, the farina within undergoes a remarkable alteration. The gluten and mucilage disappear, in a great measure, the color becomes white, and the substance becomes so friable that it crumbles into meal between the fingers. This is the great purpose of malting, and it is known to be accomplished when the plumula or acrospire has approached the end of the seed. Now the further growth must be completely stopped. Fourteen days may be reckoned the usual duration of the germinating stage of the malting operations in England; but in Scotland, where the temperature of the couch is lower, eighteen days, or even twenty-one, are sometimes required. The shorter the period within the above limits, the more advantageous is the process to the maltster, as he can turn over his capital the sooner, and his malt is also somewhat the better. Bigg is more rapid in its germination than barley, and requires to be still more carefully watched. In dry weather it is sometimes necessary to water the barley upon the couch.

Occasionally the odor disengaged from the couch is offensive, resembling that of rotten apples. This is a bad prognostic, indicating either that the barley was of bad quality, or that the workmen, through careless shovelling, have crushed a number of the grains in turning them over. Hence when the weather causes too quick germination, it is better to check it by spreading the heap out thinner than by turning it too frequently over. On comparing different samples of barley, we shall find that the best develop the germ or acrospire quicker than the radicles, and thus occasion a greater production of the saccharine principle; this conversion advances along with the acrospire, and keeps pace with it, so that the portion of the seed to which it has not reached is still in its unaltered starchy state. It is never complete for any single barleycorn till the acrospire has come to the end opposite to that from which it sprung; hence one part of the corn may be sugary, while the other is still insipid. If the grain were allowed to vegetate beyond this term, the radicles being fully one third of an inch long, the future stem would become visibly green in the exterior; it would shoot forth rapidly, the interior of the grain would become milky, with a complete exhaustion of all its useful constituents, and nothing but the husk would remain.

In France, the brewers, who generally malt their barley themselves, seldom leave it on the couch more than 8 or 10 days, which, even taking into account the warmer climate of their country, is certainly too short a period, and hence they make inferior wort to the English brewer, from the same quantity of malt.

At the end of the germination, the radicles have become 1½ longer than the barley, and are contorted so that the corns hook into one another, but the acrospire is just beginning to push through. A moderate temperature of the air is best adapted to malting; therefore it cannot be carried on well during the heat of summer or the colds of winter. Malt-floors should be placed in substantial thick-walled buildings, without access of the sun, so that a uniform temperature of 59° or 60° may prevail inside. Some recommend them to be sunk a little under the surface of the ground, if the situation be dry.

During germination a remarkable change has taken place in the substance of the grain. The glutinous constituent has almost entirely disappeared, and is supposed to have passed into the matter of the radicles, while a portion of the starch is converted into sugar and mucilage. The change is similar to what starch undergoes when dissolved in water, and digested in a heat of about 160° F. along with a little gluten.

The thick paste becomes gradually liquid, transparent, and sweet tasted, and the solution contains now, sugar and gum, mixed with some unaltered starch. The gluten suffers a change at the same time, and becomes acescent, so that only a certain quantity of starch can be thus converted by a quantity of gluten. By the artificial growth upon the malt-floor, all the gluten and albumen present in barley is not decomposed, and only about one half of the starch is converted into sugar; the other half, by a continuance of the germination, would only go to the growth of the roots and stems of the plant; but it receives its nearly complete conversion into sugar without any notable waste of substance in the brewer's operation of mashing.

The *kiln-drying.*—When the malt has become perceptibly dry to the hand upon the floor, it is taken to the kiln, and dried hard with artificial heat, to stop all further growth, and enable it to be kept, without change, for future use, at any time. The malt-kiln, which is particularly described in the next page, is a round or a square chamber, covered with perforated plates of cast iron, whose area is heated by a stove or furnace, so that not merely the plates on which the malt is laid are warmed, but the air which passes up through the stratum of malt itself, with the effect of carrying off very rapidly the moisture from the grains. The layer of malt should be about 3 or 4 inches thick, and evenly spread, and its heat should be steadily kept at from the 90th to the 100th degree of Fahrenheit's scale, till the moisture be mostly exhaled from it. During this time the malt must be turned over at first frequently, and latterly every three or four hours. When it is nearly dry, its temperature should be raised to from 145° to 165° F., and it must be kept at this heat till it has assumed the desired shade of color, which is commonly a brownish-yellow or a yellowish-brown. The fire is now allowed to die out, and the malt is left on the plates till it has become completely cool; a result promoted by the stream of cool air, which now rises up through the bars of the grate; or the thoroughly dry browned malt may, by damping the fire, be taken hot from the plates, and cooled upon the floor of an adjoining apartment. The prepared malt must be kept in a dry loft, where it can be occasionally turned over till it is used. The period of kiln-drying should not be hurried. Many persons employ two days in this operation.

According to the color and the degree of drying, malt is distributed into three sorts, pale, yellow, and brown. The first is produced when the highest heat to which it has been subjected is from 90° to 100° F.; the amber yellow, when it has suffered a heat of 122°; and the brown when it has been treated as above described. The black malt used by the porter brewer to color his beer, has suffered a much higher heat, and is partially charred. The temperature of the kiln should, in all cases, be most gradually raised, and most equably maintained. If the heat be too great at the beginning, the husk gets hard dried, and hinders the evaporation of the water from the interior substance; and should the interior be dried by a stronger heat. the husk will probably split, and the farina become of a horny texture, very refractory in the mash-tun. In general, it is preferable to brown malt, rather by a long-continued moderate heat, than by a more violent heat of shorter duration, which is apt to carbonize a portion of the mucilaginous sugar, and to damage the article. In this way, the sweet is sometimes converted into a bitter principle.

During the kiln-drying, the roots and acrospire of the barley become brittle, and fall off; and are separated by a wire sieve whose meshes are too small to allow the malt itself to pass through.

A quantity of good barley, which weighs 100 pounds, being judiciously malted, will weigh, after drying and sifting, 80 pounds. Since the raw grain, dried by itself at the same temperature as the malt, would lose 12 per cent. of its weight in water, the malt process dissipates out of these remaining 88 pounds, only 8 pounds, or 8 per cent. of the raw barley. This loss consists of—

1½ per cent. dissolved out in the steep water,
3   —   dissipated in the kiln,
3   —   by the falling of the fibrils,
½   —   of waste.

The bulk of good malt exceeds that of the barley from which it was made, by about 8 or 9 per cent.

The operation of kiln-drying is not confined to the mere expulsion of the moisture from the germinated seeds; but it serves to convert into sugar a portion of the starch which remained unchanged, and that in a twofold way; first, by the action of the gluten upon the fecula at an elevated temperature, as also by the species of roasting which the starch undergoes, and which renders it of a gummy nature. (See STARCH.) We shall have a proof of this explanation, if we dry one portion of the malt in a naturally dry atmosphere, and another in a moderately warm kiln; the former will yield less saccharine extract than the latter. Moreover, the kiln-dried malt has a peculiar, agreeable, and faintly burned taste, probably from a small portion of empy-

reumatic oil formed in the husk, and which not only imparts its flavor to the beer, but also contributes to its preservation. It is therefore obvious, that the skilful preparation of the malt must have the greatest influence both on the quantity and quality of the worts to be made from it. If the germination be pushed too far, a part of the extractible matter is wasted; if it has not advanced far enough, the malt will be too raw, and too much of its substance will remain as an insoluble starch; if it is too highly kiln-dried, a portion of its sugar will be caramelized, and become bitter; and if the sweating was imperfect or irregular, much of the barley may be rendered lumpy and useless. Good malt is distinguishable by the following characters:—

The grain is round and full, breaks freely between the teeth, and has a sweetish taste, an agreeable smell, and is full of a soft flour from end to end. It affords no unpleasant flavor on being chewed; it is not hard, so that when drawn along an oaken table across the fibres, it leaves a white streak, like chalk. It swims upon water, while unmalted barley sinks in it. Since the quality of the malt depends much on that of the barley, the same sort only should be used for one malting. New barley germinates quicker than old, which is more dried up; a couch of a mixture of the two would be irregular, and difficult to regulate.

Description of the malt-kiln.—*Figs.* 97, 98, 99, 100, exhibit the construction of a well-contrived *malt-kiln*. *Fig.* 97, is the ground plan: *fig.* 98 is the vertical section; and *figs.* 99 and 100, a horizontal and vertical section in the line of the malt-plates. The same letters denote the same parts in each of the figures. A cast-iron cupola-shaped oven is
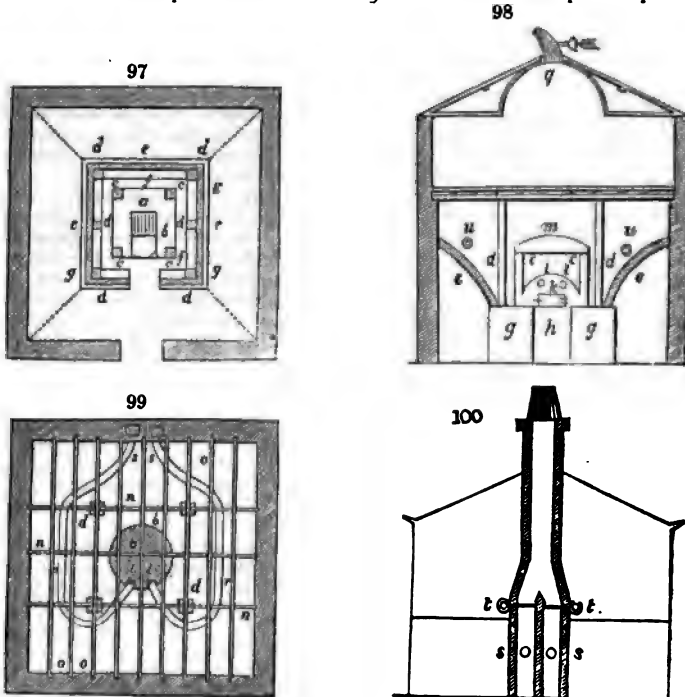
supported in the middle, upon a wall of brickwork four feet high; and beneath it, are the grate and its ash-pit. The smoke passes off through two equi-distant pipes into the chimney. The oven is surrounded with four pillars, on whose top a stone lintel is laid : *a* is the grate, 9 inches below the sole of the oven *b* ; *c c c c* are the four nine-inch strong pillars of brickwork which bear the lintel *m* ; *d d d d d d* are strong nine-inch pillars, which support the girder and joists upon which perforated plates repose ; *e* denotes a vaulted arch on each of the four sides of the oven ; *f* is the space between the kiln and the side arch, into which a workman may enter, to inspect and clean the kiln ; *g g*, the walls on either side of the kiln, upon which the arches rest; *h*, the space for the ashes to fall ; *k*, the fire-door of the kiln ; *l l*, junction-pieces to connect the pipes *r r* with the kiln; the mode of attaching them is shown in *fig.* 99. These smoke-pipes lie about three feet under the iron plates, and at the same distance from the side walls; they are supported upon iron props, which are made fast to the arches. In *fig.* 98, a

rows their section; at *s s*, *fig.* 99, they enter the chimney, which is provided with two ·gister or damper plates, to regulate the draught through the pipes. These registers ie represented by *t t*, *fig.* 100, which shows a perpendicular section of the chimney. ь *fig.* 98, is the lintel which causes the heated air to spread laterally instead of scending in one mass in the middle, and prevents any combustible particles from falling pon the iron cupola. *n n* are the main girders of iron for the iron beams *o o*, upon ·hich the perforated plates *p* lie; *q, fig.* 98, is the vapor pipe in the middle of the roof, ·hich allows the steam of the drying malt to escape. The kiln may be heated either ·ith coal or wood.

The size of this kiln is about 20 feet square; but it may be made proportionally either naller or greater. The perforated floor should be large enough to receive the contents f one steep or couch.

The perforated plate might be conveniently heated by steam pipes, laid zig-zag, or in arallel l.нes under it; or a wire-gauze web might be stretched upon such pipes. The rooden joists of a common floor would answer perfectly to support this steam-range, and he heat of the pipes would cause an abundant circulation of air. For drying the pale salt of the ale brewer, this plan is particularly well adapted.

The kiln-dried malt is sometimes ground between stones in a common corn mill, like atmeal; but it is more generally crushed between iron rollers, at least for the purposes f the London brewers.

The *crushing mill.*—The cylinder malt-mill is constructed as shown in *figs.* 101, 102. is the sloping-trough, by which the malt is let down from its bin or floor to the
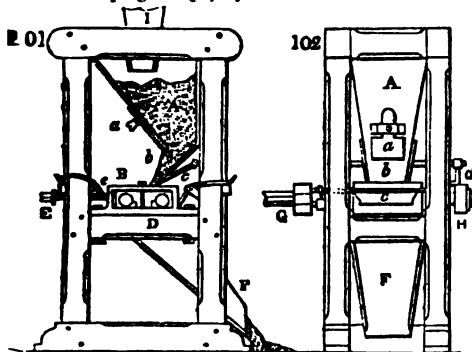
hopper A of the mill, whence it is progressively shaken in between the rollers B D. The rollers are of iron, truly cylindrical, and their ends rest in bearers of hard brass, fitted into the side frames of iron. A screw E goes through the upright, and serves to force the bearer of the one roller towards that of the other, so as to bring them closer together when the crushing effect is to be increased. G is the square end of the axis, by which one of the rollers may be turned either by the hand or by power; the other

k.erives its rotatory motion from a pair of equal-toothed wheels H, which are fitted to **J**he other end of the axes of the rollers. *d* is a catch which works into the teeth of **a** ratchet-wheel on the end of one of the rollers (not shown in this view.) The lever = strikes the trough *b* at the bottom of the hopper, and gives it the shaking motion for **J**ischarging the malt between the rollers, from the slide sluice *a*. *e e, fig.* 101, are **s**craper-plates of sheet iron, the edges of which press by a weight against the surfaces **o**f the rollers, and keep them clean.

Instead of the cylinders, some employ a crushing mill of a conical-grooved form like a **c**offee-mill, upon a large scale. (*See the general plan, infra.*)

The *mashing and boiling.*—Mashing is the operation by which the wort is extracted, **o**r eliminated from the malt, and whereby a saccharo-mucilaginous extract is made **f**rom it. The malt should not in general be ground into a fine meal, for in that case **i**t would be apt to form a cohesive paste with hot water, or to set, as it is called, and to **b**e difficult to drain. In crushed malt, the husk remains nearly entire, and thus helps **t**o keep the farinaceous particles open and porous to the action of the water. The bulk **o**f the crushed malt is about one fifth greater than that of the whole, or one bushel of **m**alt gives a bushel and a quarter of crushed malt. This is frequently allowed to lie **a** few days in a cool place, in order that it may attract moisture from the air, which it **d**oes very readily by its hygrometric power. Thus, the farinaceous substance which had **b**een indurated in the kiln, becomes soft, spongy, and fit for the ensuing process of watery **e**xtraction.

Mashing has not for its object merely to dissolve the sugar and gum already present in the malt, but also to convert into a sweet mucilage the starch which had remained **u**nchanged during the germination. We have already stated that starch, mixed with **g**luten, and digested for some time with hot water, becomes a species of sugar. This **c**onversion takes place in the mash-tun. The malted barley contains not only a portion **o**f gluten, but *diastase* more than sufficient to convert the starch contained in it, by this **m**eans, into sugar.

The researches of Payen and Persoz show, that the mucilage formed by the reaction of malt upon starch, may either be converted into sugar, or be made into permanent gum, according to the temperature of the water in which the materials are digested. We take of pale barley malt, ground fine, from 6 to 10 parts, and 100 parts of starch; we heat, by means of a water-bath, 400 parts of water in a copper, to about 80° F.; we then stir in the malt, and increase the heat to 140° F., when we add the starch, and stir well together. We next raise the temperature to 158°, and endeavor to maintain it constantly at that point, or at least to keep it within the limits of 167° on the one side, and 158° on the other. At the end of 20 or 30 minutes, the original milky and pasty solution becomes thinner, and soon after as fluid nearly as water. This is the moment in which the starch is converted into gum, or into that substance which the French chemists call *dextrine*, from its power of polarizing light to the right hand, whereas common gum does it to the left. If this merely mucilaginous solution, which seems to be a mixture of gum with a little liquid starch and sugar, be suitably evaporated, it may serve for various purposes in the arts to which gum is applied, but with this view, it must be quickly raised to the boiling point, to prevent the farther operation of the malt upon it. If we wish, on the contrary, however, to promote the saccharine fermentation, for the formation of beer, we must maintain the temperature at between 158° and 167° for three or four hours, when the greatest part of the gum will have passed into sugar, and by evaporation of the liquid at the same temperature, a starch sirup may be obtained like that procured by the action of sulphuric acid upon starch. The substance, which operates in the formation of sugar, or is the peculiar ferment of the sugar fermentation, may be considered as a residuum of the gluten or vegetable albumen in the germinating grain: it is reckoned by Payen and Persoz, a new proximate principle called *diastase*, which is formed during malting, in the grains of barley, oats, and wheat, and may be separated in a pure state, if we moisten the malt flour for a few minutes in cold water, press it out strongly, filter the solution, and heat the clear liquid in a water bath, to the temperature of 158°. The greater part of that albuminous azotized substance is thus coagulated, and is to be separated by a fresh filtration; after which, the clear liquid is to be treated with alcohol, when a flocky precipitate appears, which is *diastase*. To purify it still further, especially from the azotized matter, we should dissolve it in water, and precipitate again with alcohol. When dried at a low temperature, it appears as a solid white substance, which contains no azote; is insoluble in alcohol, but dissolves in water and proof spirit. Its solution is neutral and tasteless; when left to itself, it changes with greater or less rapidity according to the temperature, and becomes sour at a temperature of from 149° to 167°. It has the property of converting starch into gum (dextrine) and sugar, and indeed, when sufficiently pure, with such energy that one part of it disposes 2000 parts of dry starch to that change, but it operates the quicker the greater its quantity. Whenever the solution of diastase with starch or with dextrine is heated to the boiling point, it loses the sugar-fermenting property. One hundred parts of well-malted starch appear to contain about one part of this substance.

We can now understand the theory of malting, and the limits between which the temperature of the liquor ought to be maintained in this operation; namely, the range between 157° and 160° F. It has been ascertained as a principle in mashing, that the best and soundest extract of the malt is to be obtained, first of all, by beginning to work with water at the lowest of these heats, and to conclude the mash with water at the highest. Secondly, not to operate the extraction at once with the whole of the water that is to be employed; but with separate portions and by degrees. The first portion is added with the view of penetrating equally the crushed malt, and of extracting the already formed sugar; the next for effecting the sugar fermentation by the action of the diastase.* By this means, also, the starch is not allowed to run into a cohesive paste, and the extract is more easily drained from the poorer mass, and comes off in the form of a nearly limpid wort. The thicker, moreover, or the less diluted the mash is, so much the easier is the wort fined in the boiler or copper by the coagulation of the albuminous matter: these principles illustrate, in every condition, the true mode of conducting the mashing process; but different kinds of malt require a different treatment. Pale and slightly kilned malt requires a somewhat lower heat than malt highly kilned, because the former has more undecomposed starch, and is more ready to become pasty. The former also, for the same reason, needs a more leisurely infusion than the latter, for its conversion into mucilaginous sugar. The more sugar the malt contains, the more is its saccharine fermentation accelerated by the action of the diastase. What has been here said of pale malt, is still more applicable to the case of a mixture of raw grain with malt, for it requires still gentler heats, and more cautious treatment.

III. The mash-tun is a large circular tub with a double bottom; the uppermost of which is called a false bottom, and is pierced with many holes. There is a space of about 2 or 3 inches between the two, into which the stopcocks enter, for letting in the water and drawing off the wort. The holes of the false bottom should be burned, and not bored

to prevent the chance of their filling up by the swelling of the wood, which would obstruct the drainage: the holes should be conical, and largest below, being about ⅜ of an inch there, and ⅛ at the upper surface. The perforated bottom must be fitted truly at the sides of the mash-tun, so that no grains may pass through. The mashed liquor is let off into a large back, from which it is pumped into the wort coppers. The mash-tun is provided with a peculiar rotatory apparatus for agitating the crushed grains and water together, which we shall presently describe. The size of the wort copper is proportional to the amount of the brewing, and it must, in general, be at least so large as to operate upon the whole quantity of wort made from one mashing; that is, for every quarter of malt mashed, the copper should contain 140 gallons. The mash-tun ought to be at least a third larger, and of a conical form, somewhat wider below than above. The quantity of water to be employed for mashing, or the extraction of the wort, depends upon the greater or less strength to be given to the beer. The seeds of the crushed malt, after the wort is drawn off, retain still about 32 gallons of water for every quarter of malt. In the boiling, and evaporation from the coolers, 40 gallons of water are dissipated from one quarter of malt; constituting 72 gallons in all. If 13 quarters of barley be taken to make 1500 gallons of beer, 2400 gallons of water must therefore be required for the mashing. This example will give an idea of the proportions for an ordinary quality of beer.

When the mash is to begin, the copper must be filled with water, and heated. As soon as the water has attained the heat of 145° in summer, or 167° in winter, 600 gallons of it are to be run off into the mash-tun, and the 13 quarters of crushed malt are to be gradually thrown in and well intermixed by proper agitation, so that it may be uniformly moistened, and no lumps may remain. After continuing the agitation in this way for one half or three quarters of an hour, the water in the copper will have approached to its boiling point, when 450 gallons at the temperature of about 200° are to be run into the mash-tun, and the agitation is to be renewed till the whole assumes an equally fluid state: the tun is now to be well covered for the preservation of its heat, and to be allowed to remain at rest for an hour, or an hour and a half. The mean temperature of this mash may be reckoned at about 145°. The time which is necessary for the transmuting heat of the remaining starch into sugar depends on the quality of the malt. Brown malt requires less time than pale malt, and still less than a mixture with raw grain, as already explained. After the mash has rested the proper time, the tap of the tun is opened, and the clear wort is to be drawn out into the under back. If the wort that first flows is turbid, it must be returned into the tun, till it runs clear. The amount of this first wort may be about 675 gallons. Seven hundred and fifty gallons of water, at the temperature of 200°, are now to be introduced up through the drained malt, into the tun, and the mixture is to be agitated till it becomes uniform, as before. The mash-tun is then to be covered, and allowed to remain at rest for an hour. The temperature of this mash is from 167° to 174°. While the second mash is making, the worts of the first are to be pumped into the wort copper, and set a-boiling as speedily as possible. The wort of the second mash is to be drawn off at the proper time, and added to the copper as fast as it will receive it, without causing the ebullition to stop.

A third quantity of water amounting to 600 gallons, at 200°, is to be introduced into the mash-tun, and after half an hour is to be drawn off, and either pumped into the wort copper, or reserved for mashing fresh malt, as the brewer may think fit.

The quantity of extract, per barrel weight, which a quarter of malt yields to wort, amounts to about 84 lbs. The wort of the first extract is the strongest; the second contains, commonly, one half the extract of the first; and the third, one half of the second; according to circumstances.

To measure the degrees of concentration of the worts drawn off from the tun, a particular form of hydrometer, called a saccharometer, is employed, which indicates the number of pounds weight of liquid contained in a barrel of 36 gallons imperial measure. Now, as the barrel of water weighs 360 lbs., the indication of the instrument, when placed in any wort, shows by how many pounds a barrel of that wort is heavier than a barrel of water; thus, if the instrument sinks with its poise till the mark 10 is upon a line with the surface of the liquid, it indicates that a barrel of that wort weighs ten pounds more than a barrel of water. See SACCHAROMETER.

Or, supposing the barrel of wort weighs 396 lbs., to convert that number into specific gravity, we have the following simple rule:—

$$360 : 396 :: 100 : 1\cdot100;$$

at which density, by my experiments, the wort contains 25 per cent. of solid extract.

Having been employed to make experiments on the density of worts, and the fermentative changes which they undergo, for the information of a committee of the House of Commons, which sat in July and August, 1830, I shall here introduce a short abstract of that part of my evidence which bears upon the present subject.

My first object was to clear up the difficulties which, to common apprehension, hung

over the matter, from the difference in the scales of the saccharometers in use among the brewers and distillers of England and Scotland. I found that one quarter of good malt would yield to the porter-brewer a barrel Imperial measure of wort, at the concentrated specific gravity of 1·234. Now, if the decimal part of this number be multiplied by 360, being the number of pounds weight of water in the barrel, the product will denote the excess in pounds, of the weight of a barrel of such concentrated wort, over that of a barrel of water; and that product is, in the present case, 84·24 pounds.

Mr. Martineau, jun., of the house of Messrs. Whitbread and Company, and a gentleman connected with another great London brewery, had the kindness to inform me that their average product from a quarter of malt was a barrel of 84 lbs. gravity. It is obvious, therefore, that by taking the mean operation of two such great establishments, I must have arrived very nearly at the truth.

It ought to be remarked that such a high density of wort as 1·234 is not the result of any direct experiment in the brewery, for infusion of malt is never drawn off so strong; that density is deduced by computation from the quantity and quality of several successive infusions; thus, supposing a first infusion of the quarter of malt to yield a barrel of specific gravity 1·112, a second to yield a barrel at 1·091, and a third a barrel at 1·031, we shall have three barrels at the mean of these three numbers, or one barrel at their sum, equal to 1·234.

I may here observe that the arithmetical mean or sum is not the true mean or sum of the two specific gravities; but this difference is either not known or disregarded by the brewers. At low densities this difference is inconsiderable, but at high densities it would lead to serious errors. At specific gravity 1·231, wort or sirup contains one half of its weight of solid pure saccharum, and at 1·1045 it contains one fourth of its weight; but the brewer's rule, when here applied, gives for the mean specific gravity $1·1155 = \dfrac{1·231 + 1·000}{2}$. The contents in solid saccharine matter at that density are however 27¼

per cent., showing the rule to be 2¼ lbs. wrong in excess on 100 lbs., or 9 lbs. per barrel.

The specific gravity of the solid dry extract of malt wort is 1·264; it was taken in oil of turpentine, and the result reduced to distilled water as unity. Its specific volume is 0·7911, that is, 10 lbs. of it will occupy the volume of 7·911 lbs. of water. The mean specific gravity, by computation of a solution of that extract in its own weight of water, is 1·1166; but by experiment, the specific gravity of that solution is 1·216, showing considerable condensation of volume in the act of combination with water.

The following Table shows the relation between the specific gravities of solutions of malt extract, and the per-centage of solid extract they contain:

Extr Malt.		Water.	Malt Extract in 100.	Sugar in 100.	Specific gravity.
600	+	600	50·00	47·00	1·2160
600	+	900	40·0	37·00	1·1670
600	+	1200	33·3	31·50	1·1350
600	+	1500	28·57	26·75	1·1130
600	+	1800	25·00	24·00	1·1000

The extract of malt was evaporated to dryness, at a temperature of about 250° F., without the slightest injury to its quality, or any empyreumatic smell. Bate's tables have been constructed on solutions of sugar, and not with solutions of extract of malt, or they agree sufficiently well with the former, but differ materially from the latter. Allan's tables give the amount of a certain form of solid saccharine matter extracted from malt, and dried at 175° F., in correspondence to the specific gravity of the solution; but I have found it impossible to make a solid extract from infusions of malt, except at much higher temperatures than 175° F. Indeed, the numbers on Allan's saccharometer scale clearly show that his extract was by no means dry: thus, at 1·100 of gravity he assigns 29·669 per cent. of solid saccharine matter; whereas there is at that density of solid extract only 25 per cent. Again, at 1·135, Allan gives 40 parts per cent. of solid extract, whereas there are only 33¼ present.

By the triple mashing operations above described, the malt is so much exhausted that it can yield no further extract useful for strong beer or porter. A weaker wort might no doubt still be drawn off for small beer, or for contributing a little to the strength of the next mashing of fresh malt. But this I believe is seldom practised by respectable brewers, as it impoverishes the grains which they dispose of for feeding cattle.

The wort should be transferred into the copper, and made to boil as soon as possible, for if it remains long in the under-back it is apt to become acescent. The steam moreover raised from it in the act of boiling serves to screen it from the oxygenating or acidifying influence of the atmosphere. Until it begins to boil, the air should be excluded by some kind of a cover.

Sometimes the first wort is brewed by itself into strong ale, the second by itself into an intermediate quality; and the third into small beer; but this practice is not much followed in this country.

We shall now treat of the boiling in of the hops. The wort drawn from the mash-tun, whenever it is pumped into the copper, must receive its allowance of hops. Besides evaporating off a portion of the water, and thereby concentrating the wort, boiling has a twofold object. In the first place, it coagulates the albuminous matter, partly by the heat, and partly by the principles in the hops, and thereby causes a general clarification of the whole mass, with the effect of separating the muddy matters in a flocculent form. Secondly, during the ebullition, the residuary starch and hordeine of the malt are converted into a limpid sweetish mucilage, the *dextrine* above described; while some of the glutinous stringy matter is rendered insoluble by the tannin principle of the hops, which favors still further the clearing of the wort. By both operations the keeping quality of the beer is improved. This boil must be continued during several hours; a longer time for the stronger, and a shorter for the weaker beers. There is usually one seventh or one sixth part of the water dissipated in the boiling copper. This process is known to have continued a sufficient time, if the separation of the albuminous flocks is distinct, and if these are found, by means of a proof gauge suddenly dipped to the bottom, to be collected there, while the supernatant liquor has become limpid. Two or three hours' boil is deemed long enough in many well-conducted breweries; but in some of those in Belgium, the boiling is continued from 10 to 15 hours, a period certainly detrimental to the aroma derived from the hop.

Many prefer adding the hops when the wort has just come to the boiling point. Their effect is to repress the further progress of fermentation, and especially the passage into the acetous stage, which would otherwise inevitably ensue in a few days. In this respect, no other vegetable production hitherto discovered can be a substitute for the hop. The odorant principle is not so readily volatilized as would at first be imagined; for when hop is mixed with strong beer wort and boiled for many hours, it can still impart a very considerable degree of its flavor to weaker beer. By mere infusion in hot beer or water, without boiling, the hop loses very little of its soluble principles. The tannin of the hop combines, as we have said, with the vegetable albumen of the barley, and helps to clarify the liquor. Should there be a deficiency of albumen and gluten, in consequence of the mashing having been done at such a heat as to have coagulated them beforehand, the defect may be remedied by the addition of a little gelatine to the wort copper, either in the form of calf's foot, or of a little isinglass. If the hops be boiled in the wort for a longer period than 5 or 6 hours, they lose a portion of their fine flavor; but if their natural flavor be rank, a little extra boiling improves it. Many brewers throw the hops in upon the surface of the boiling wort, and allow them to swim there for some time, that the steam may penetrate them, and open their pores for a complete solution of their principles when they are pushed down into the liquor. It is proper to add the hops in considerable masses, because, in tearing them asunder, some of the lupuline powder is apt to be lost.

The quantity of hop to be added to the wort varies according to the strength of the beer, the length of time it is to be kept, or the heat of the climate where it is intended to be sent. For strong beer, 4½ lbs. of hops are required to a quarter of malt, when it is to be highly aromatic and remarkably clear. For the stronger kinds of ale and porter, the rule, in England, is to take a pound of hops for every bushel of malt, or 8 lbs. to a quarter. Common beer has seldom more than a quarter of a pound of hops to the bushel of malt.

It has been attempted to form an extract of hops by boiling in covered vessels, so as not to lose the oil, and to add this instead of the hop itself to the beer. On the great scale this method has no practical advantage, because the extraction of the hop is perfectly accomplished during the necessary boiling of the wort, and because the hop operates very beneficially, as we have explained, in clarifying the beer. Such an extract, moreover, could be easily adulterated.

Of the Coolers.—The contents of the copper are run into what is called the hop-back, on the upper part of which is fixed a drainer, to keep back the hops. The pump is placed in the hop-back, for the purpose of raising the wort to the coolers, usually placed in an airy situation upon the top of the brewery. Two coolers are indispensable when we make two kinds of beer from the same brewing, and even in single brewings, called *gyles*, if small beer is to be made. One of these coolers ought to be placed above the level of the other. As it is of great consequence to cool the worts down to the fermenting pitch as fast as possible, various contrivances have been made for effecting this purpose. The common cooler is a square wooden cistern, about 6 inches deep, and of such an extent of surface that the whole of one boil may only occupy 2 inches, or thereabouts, of depth in it. For a quantity of wort equal to about 1500 gallons its area should be at least 54 feet long and 20 feet wide. The seams of

the cooler must be made perfectly water-tight and smooth, so that no liquor may lodge in them when they are emptied. The utmost cleanliness is required, and an occasional sweetening with lime-water.

The hot wort reaches the cooler at a temperature of from 200° to 208°, according to the power of the pump. Here it should be cooled to the proper temperature for the fermenting tun, which may vary from 54° to 64°, according to circumstances. The refrigeration is accomplished by the evaporation of a portion of the liquor: it is more rapid in proportion to the extent of the surface, to the low temperature, and the dryness of the atmosphere surrounding the cooler. The renewal of a body of cool dry air by the agency of a fan, may be employed with great advantage. The cooler itself must be so placed that its surface shall be freely exposed to the prevailing wind of the district, and be as free as possible from the eddy of surrounding buildings. It is thought by many that the agitation of the wort during its cooling is hurtful. Were the roof made moveable, so that the wort could be readily exposed, in a clear night, to the aspect of the sky, it would cool rapidly by evaporation, on the principles explained by Dr. Wells, in his " Essay on Dew."

When the cooling is effected by evaporation alone, the temperature falls very slowly, even in cold air, if it be loaded with moisture. But when the air is dry, the evaporation is vigorous, and the moisture exhaled does not remain incumbent on the liquor, as in damp weather, but is diffused widely in space. Hence we can understand how wort cools so rapidly in the spring and autumn, when the air is generally dry, and even more quickly than in winter, when the air is cooler, but loaded with moisture. In fact, the cooling process goes on better when the atmosphere is from 50° to 55°, than when it falls to the freezing point, because in this case, if the air be still, the vapors generated remain on the surface of the liquor, and prevent further evaporation. In summer the cooling can take place only during the night.

In consequence of the evaporation during this cooling process, the bulk of the worts is considerably reduced; thus, if the temperature at the beginning was 208°, and if it be at the end 64°, the quantity of water necessary to be evaporated to produce this refrigeration would be nearly ½ of the whole, putting radiation and conduction of heat out of the question. The effect of this will be a proportional concentration of the beer.

The period of refrigeration in a well-constructed cooler, amounts to 6 or 7 hours in favorable weather, but to 12 or 15 in other circumstances. The quality of the beer is much improved by shortening this period; because, in consequence of the great surface which the wort exposes to the air, it readily absorbs oxygen, and passes into the acetous fermentation with the production of various mouldy spots; an evil to which ill-hopped beer is particularly liable. Various schemes have been contrived to cool wort, by transmitting it through the convolutions of a pipe immersed in cold water. The best plan is to expose the hot wort for some hours freely to the atmosphere and the cooler, when the loss of heat is most rapid by evaporation and other means, and when the temperature falls to 100°, or thereby, to transmit the liquor through a zig-zag pipe, laid almost horizontally in a trough of cold water. The various methods described under *Refrigerator* are more complex, but they may be practised in many situations with considerable advantage.

Whilst the wort reposes in the cooler, it lets fall a slight sediment, which consists partly of fine flocks of coagulated albumen combined with tannin, and partly of starch, which had been dissolved at the high temperature, and separates at the lower. The wort should be perfectly limpid, for a muddy liquor never produces transparent beer. Such beer contains, besides mucilaginous sugar and gum, usually some starch, which even remains after the fermentation, and hinders its clarifying, and gives it a tendency to sour. The wort contains more starch the hotter it has been mashed, the less hops have been added, and the shorter time it has been boiled. The presence of starch in the wort may be made manifest by adding a little solution of iodine in alcohol to it, when it will become immediately blue. We thus see that the tranquil cooling of wort in a proper vessel has an advantage over cooling it rapidly by a refrigeratory apparatus. When the wort is sufficiently cool, it is let down into the fermenting tun. In this transfer the cooling might be carried several degrees lower, were the wort made to pass down through a tube enclosed in another tube, along which a stream of cold water is flowing in the opposite direction, as we have described in the sequel of ACETIC ACID. These fermenting tuns are commonly called *gyle-tuns*, or working tuns, and are either square or circular, the latter being preferable on many accounts.

IV. *Of the Fermentation.*—In the great London breweries, the size of these fermenting tuns is such that they contain from 1200 to 1500 barrels. The quantity of wort introduced at a time must, however, be considerably less than the capacity of the vessel, to allow room for the head of yeast which rises during the process; if the vessel be cylindrical, this head is proportional to the depth of the worts. In certain kinds of

fermentation, it may rise to a third of that depth. In general, the fermentation proceeds more uniformly and constantly in large masses, because they are little influenced by vicissitudes of temperature; smaller vessels, on the other hand, are more easily handled. The *general* view of fermentation will be found under that title; I shall here make a few remarks on what is peculiar to beer. During the fermentation of wort, a portion of its saccharine matter is converted into alcohol, and wort thus changed is beer. It is necessary that this conversion of the sugar be only partial, for beer which contains no undecomposed sugar would soon turn sour, and even in the casks its alcohol undergoes a slow fermentation into vinegar. The amount of this excess of sugar is greater in proportion to the strength of the wort, since a certain quantity of alcohol, already formed, prevents the operation of the ferment on the remaining wort. Temperature has the greatest influence upon the fermentation of wort. A temperature of from 55° to 60° of the liquor, when that of the atmosphere is 55°, is most advantageous for the commencement. The warmth of the wort as it comes into the gyle-tun must be modified by that of the air in the apartment. In winter, when this apartment is cold, the wort should not be cooled under 64° or 60°, as in that case the fermentation would be tedious or interrupted, and the wort liable to spoil or become sour. In summer, when the temperature of the place rises to above 75°, the wort should be cooled, if possible, down to 55°, for which purpose it should be let in by the system of double pipes, above mentioned. The higher the temperature of the wort, the sooner will the fermentation begin and end, and the less is it in our power to regulate its progress. The expert brewer must steer a middle course between these two extremes, which threaten to destroy his labors. In some breweries a convoluted pipe is made to traverse or go round the sides of the gyle-tun, through which warm water is allowed to flow in winter, and cold in summer, so as to modify the temperature of the mass to the proper fermenting pitch. If there be no contrivance of this kind, the apartment may be cooled in summer, by suspending wet canvass opposite the windows in warm weather, and kindling a small stove within it in cold.

When the wort is discharged into the gyle-tun, it must receive its dose of yeast, which has been previously mixed with a quantity of the wort, and left in a warm place till it has begun to ferment. This mixture, called *lobb*, is then to be put into the tun, and stirred well through the mass. The yeast should be taken from similar beer. Its quantity must depend upon the temperature, strength, and quantity of the wort. In general, one gallon of yeast is sufficient to set 100 gallons of wort in complete fermentation. An excess of yeast is to be avoided, lest the fermentation should be too violent, and be finished in less than the proper period of 6 or 8 days. More yeast is required in winter than in summer; for, at a temperature of 50°, a double quantity may be used to that at 68°.

Six or eight hours after adding the yeast, the tun being meanwhile covered, the fermentation becomes active : a white milky-looking froth appears, first on the middle, and spreads gradually over the whole surface; but continues highest in the middle, forming a frothy elevation, the height of which increases with the progress of the fermentation, and whose color gradually changes to a bright brown, the result, apparently, of the oxydation of the extractive contained in this yeasty top. This covering screens the wort from the contact of the atmospherical air. During this time, there is a perpetual disengagement of carbonic acid gas, which is proportional to the quantity of sugar converted into alcohol. The warmth of the fermenting liquid increases at the same time, and is at a maximum when the fermentation has come to its highest point. This increase of temperature amounts to from 9° to 14° or upwards, and is the greater the more rapid the fermentation. But in general, the fermentation is not allowed to proceed so far in the gyle-tun, for after it is advanced a little way, the beer is *cleansed*, that is, drawn off into other vessels, which are large barrels set on end, with large openings in their top, furnished with a sloping tray for discharging an excess of yeast into the wooden trough, in which the *stillions* stand. These *stillions* are placed in communication with a store-tub, which keeps them always full, by hydrostatic pressure, so that the head of yeast may spontaneously flow over, and keep the body of liquor in the cask clean. This apparatus will be explained in describing the brewery plant. See the *figures, infra*.

It must be observed, that the quantity of yeast, and the heat of fermentation, differ for every different quality of beer. For mild ale, when the fermentation has reached 75° its first flavor begins; at 80° the flavor increases; at 85° it approaches the high flavor; at 90° it is high; but it may be carried to 100° and upwards, for particular purposes. A wort of 30lbs. per barrel (sp. gr. 1·088), ought to increase about 15°, so that in order to arrive at 80°, it should be set at 65°. The quantity of yeast for such an ale should be from 2 to 3 lbs. per barrel. The higher the heat, the less yeast is necessary. If the heat of the fermentation should at any time fall, it must be raised by a supply of fresh yeast, well stirred in; but this practice is not advisable in general, because rousing the worts in the gyle-tun is apt to communicate a rank flavor of yeast to the ale. It is the practice of many experienced brewers to look every 2 hours into the

gyle-tun, chiefly with the view of observing the progress of the heat, which is low at first, but afterwards often increases half a degree per hour, and subsequently declines, as the fermentation approaches its conclusion, till at length the heat becomes uniform, or sometimes decreases, before the fermentation is finished, especially where the quantity operated upon is small.

Some brewers recommend, when the fermentation is carried to its utmost period, to add about 7 lbs. of wheat or bean flour to a gyle-tun of 25 or 30 barrels, at the time of cleansing, so as to quicken the discharge of the yeast, by disengagement of more carbonic acid. The flour should be whisked up in a pail, with some of the beer, till the lumps are broken, and then poured in. By early cleansing, the yeast is preserved longer in a state proper for a perfect fermentation than by a contrary practice.

For old ale, which is to be long kept, the heat of the fermentation should not exceed 75°, but a longer time is required to complete the fermentation and ensure the future good flavor of the ale.

For porter, the general practice is, to use from 4 to 4½ lbs. of hops per barrel for keeping; though what is termed mild or mixing porter, has not more than 3 or 3½ lbs. The heat of fermentation must not exceed 70°, and begin about 60°. If the heat tend to increase much above that pitch in the gyle-tun, the porter should be cleansed, by means of the stillions. At this period of the fermentation, care should be taken that the sweetness of the malt be removed, for which purpose more yeast may be used than with any other beer of the same strength. The quantity is from 3 to 4 lbs. per barrel, rousing the wort in the gyle-tun every 2 hours in the day-time.

When the plan of cleansing casks is not employed, the yeast is removed from the surface of the fermenting tun by a skimmer, and the clear beer beneath is then drawn off into the ripening tuns, called store-vats, in which it is mixed up with different brewings, to suit the taste of the customers. This transfer must take place whenever the extrication of carbonic acid has nearly ceased; lest the alcohol formed should dissolve some of the floating yeast, acquire thereby a disagreeable taste, and pass partially into the acetous state.

In this process, during the formation of vinous spirit at the expense of the sugar, the albumen and gluten diffused through the beer, being acted upon by the alcohol, become insoluble; one portion of them is buoyed to the top with the carbonic acid gas, to form the frothy yeast; and another portion falls to form the bottom barm. The former consists of the same materials as the wort, with a large proportion of gluten, which forms its active constituent; the latter is a peculiar deposite, consisting of the same gluten mixed with the various dense impurities of the wort, and may be also used as a ferment, but is cruder than the floating yeast. The amount of yeast is proportional to the activity of the fermentation, or extrication of carbonic acid gas, as also to the heat of the mashing process, and the quantity of starch or flour unaltered by germination. Pale malt affords, usually, more yeast than malt highly kilned. When the yeast becomes excessive, from too violent fermentation, it should be skimmed off from time to time, which will tend to cool the liquor and moderate the intestine changes.

After the beer is let down into the close store-tuns in the cellar, an obscure fermentation goes on, for a considerable period, in its body, which increases its spirituous strength, and keeps up in it a constant impregnation of carbonic acid gas, so as to render it lively and agreeable to the taste, when it is casked off for sale. It would appear that beer is never stationary in quality, while it is contained in the tuns; for the moment when it ceases to improve by the decomposition of its residuary sugar, it begins to degenerate into vinegar. This result may be produced either by the exhaustion of the saccharine, or by the fermentative matter. The store cellar should therefore be under ground, free from alternations of temperature, vibrations of carriages, and as cool as possible. In the great London breweries the fermentation is rendered very complete in the cleansing butts; so that a slow and steady ripening is ensured in the great store-tuns. The gyle-tuns are too capacious to permit the fermentation to be finished, with either safety or sufficient despatch in them.

V. OF RIPENING DIFFERENT KINDS OF BEER.—The varieties of beer depend either upon the difference of their materials, or from a different management of the brewing processes.

With regard to the materials, beers differ in the proportion of their malt, hops, and water; and in the different kinds of malt or other grain. To the class of table or small beers, all those sorts may be referred whose specific gravity does not exceed 1·025, which contain about 5 per cent. of malt extract, or nearly 18 pounds per barrel. Beers of middling strength may be reckoned those between the density of 1·025 and 1·040; which contain at the average 7 per cent. or 25 pounds per barrel. The latter may be made with 400 quarters of malt to 1500 barrels of beer. Stronger beers have a specific gravity of from 1·050 to 1·080, and take from 45 to 75 quarters of malt to the same quantity of beer. The strongest beer found in the market is some of the English and Scotch ales, for which from 18 to 27 quarters of malt are taken for 1500

gallons of beer. Good porter requires from 16 to 18 quarters for that quantity. Beer s are sometimes made with the addition of other farinaceous matter to the malt; but when the latter constitutes the main portion of the grain, the malting of the other kinds of corn becomes unnecessary, for the diastase of the barley-malt changes the starch into sugar during the mashing operation. Even with entirely raw grain, beer is made in some parts of the Continent, the brewers trusting the conversion of the starch into sugar to the action of the gluten alone, at a low mashing temperature, on the principle of Saussure's and Kirchoff's researches.

The color of the beer depends upon the color of the malt, and the duration of the boil in the copper. The pale ale is made, as we have stated, from steam or sun-dried malt, and the young shoots of the hop; the deep yellow ale from a mixture of pale yellow and brown malt; and the dark brown beer from well-kilned and partly carbonized malt, mixed with a good deal of the pale, to give body. The longer and more strongly heated the malt has been in the kiln, the less weight of extract, *cæteris paribus*, does it afford. In making the fine mild ales, high temperatures ought to be avoided, and the yeast ought to be skimmed off, or allowed to flow very readily from its top, by means of the cleansing butt system, so that little ferment being left in it to decompose the rest of the sugar, the sweetness may remain unimpaired. With regard to porter, in certain breweries, each of the three kinds of malt employed for it is separately mashed, after which the first and the half of the second wort is boiled along with the whole of the hops, and thence cooled and set to ferment in the gyle-tun. The third drawn wort, with the remaining half of the second, is then boiled with the same hops, saved by the drainer, and, after cooling, added to the former in the gyle-tun, when the two must be well roused together.

It is obvious, from the preceding development of principles, that all amylaceous and saccharine materials, such as potatoes, beans, turnips, as well as cane and starch sirup, molasses, &c., may be used in brewing beer. When, however, a superior quality of brown beer is desired, malted barley is indispensable, and even with these substitutes a mixture of it is most advantageous. The washed roots of the common carrot, of the red and yellow beet, or of the potato, must be first boiled in water, and then mashed into a pulp. This pulp must be mixed with water in the copper, along with wheaten or oat meal, and the proper quantity of hops, then boiled during 8 or 9 hours. This wort is to be cooled in the usual way, and fermented, with the addition of yeast. A much better process is that now practised, on a considerable scale, at Strasbourg, in making the ale, for which that city is celebrated. The mashed potatoes are mixed with from a twentieth to a tenth of their weight of finely ground barley malt, and some water. The mixture is exposed, in a water-bath, to a heat of 160° F. for four hours, whereby it passes into a saccharine state, and may then be boiled with hops, cooled, and properly fermented into good beer.

Maize, or Indian corn, has also been employed to make beer; but its malting is somewhat difficult on account of the rapidity and vigor with which its radicals and plumula sprout forth. The proper mode of causing it to germinate is to cover it, a few inches deep, with common soil, in a garden or field, and to leave it there till the bed is covered with green shoots of the plant. The corn must be then lifted, washed, and exposed to the kiln.

The Difference of the Fermentation.—The greater or less rapidity with which the worts are made to ferment has a remarkable influence upon the quality of the beer, especially in reference to its fitness for keeping. The wort is a mucilaginous solution in which the yeasty principles, eliminated by the fermentation, will, if favored by regular and slow intestine movements, completely rise to the surface, or sink to the bottom, so as to leave the body fine. But, when the action is too violent, these barmy glutinous matters get comminuted and dispersed through the liquor, and can never afterwards be thoroughly separated. A portion of the same feculent matter becomes, moreover, permanently dissolved, during this furious commotion, by the alcohol that is generated. Thus the beer loses not merely its agreeable flavor and limpidity, but is apt to spoil from the slightest causes. The slower, more regularly progressive, and less interrupted, therefore, the fermentation is, so much better will the product be.

Beer, in its perfect condition, is an excellent and healthful beverage, combining, in same measure, the virtues of water, of wine, and of food, as it quenches thirst, stimulates, cheers, and strengthens. The vinous portion of it is the alcohol, proceeding from the fermentation of the malt sugar. Its amount, in common strong ale or beer, is about 4 per cent., or four measures of spirits, specific gravity 0·825 in 100 measures of the liquor. The best brown stout porter contains 6 per cent., the strongest ale even 8 per cent.; but common beer only one. The nutritive part of the beer is the undecomposed malt-sugar, and the starch-gum, not changed into sugar. Its quantity is very variable, according to the original starch of the wort, the length of the fermentation, and the age of the beer.

The main feature of good beer is fine color and transparency; the production of which is an object of great interest to the brewer. Attempts to clarify it in the cask seldom fail to do it harm. The only thing that can be used with advantage for flowing foul or muddy beer, is isinglass. For porter, as commonly brewed, it is frequently had recourse to. A pound of good isinglass will make about 12 gallons of finings. It is cut into slender shreds, and put into a tub with as much vinegar or hard beer as will cover it, in order that it may swell and dissolve. In proportion as the solution proceeds, more beer must be poured upon it, but it need not be so acidulous as the first, because, when once well softened by the vinegar, it readily dissolves. The mixture should be frequently agitated with a bundle of rods, till it acquires the uniform consistence of thin treacle, when it must be equalized still more by passing through a tammy cloth, or a sieve. It may now be made up with beer to the proper measure of dilution. The quantity generally used is from a pint to a quart per barrel, more or less, according to the foulness of the beer. But before putting it into the butt, it should be diffused through a considerable volume of the beer with a whisk, till a frothy head be raised upon it. It is in this state to be poured into the cask, briskly stirred about; after which the cask must be bunged down for at least 24 hours, when the liquor should be limpid. Sometimes the beer will not be improved by this treatment; but this should be ascertained beforehand, by drawing off some of the beer into a cylindric jar or vial, and adding to it a little of the finings. After shaking and setting down the glass, we shall observe whether the feculencies begin to collect in flocky parcels, which slowly subside; or whether the isinglass falls to the bottom without making any impression upon the beer. This is always the case when the fermentation is incomplete, or a secondary decomposition has begun. Mr. Jackson has accounted for this clarifying effect of isinglass in the following way.

The isinglass, he thinks, is first of all rather diffused mechanically, than chemically dissolved, in the sour beer or vinegar, so that when the finings are put into the foul beer, the gelatinous fibres, being set free in the liquor, attract and unite with the floating feculencies, which before this union were of the same specific gravity with the beer, and therefore could not subside alone; but having now acquired additional weight by the coating of fish glue, precipitate as a flocculent magma. This is Mr. Jackson's explanation; to which I would add, that if there be the slightest disengagement of carbonic acid gas, it will keep up an obscure locomotion in the particles, which will prevent the said light impurities, either alone or when coated with isinglass, from subsiding. The beer is then properly enough called *stubborn* by the coopers. But the true theory of the action of isinglass is, that the tannin of the hops combines with the fluid gelatine, and forms a flocculent mass, which envelopes the muddy particles of the beer, and carries them to the bottom as it falls, and forms a sediment. When, after the finings are poured in, no proper precipitate ensues, it may be made to appear by the addition of a little decoction of hop.

Mr. Richardson, the author of the well-known brewer's saccharometer, gives the following as the densities of different kinds of beer :—

Beer.	Pounds per Barrel.	Specific Gravity.
Burton ale, 1st sort - - -	40 to 43	1·111 to 1·120
2d ditto - - -	35 to 40	1·097 to 1·111
3d ditto - - -	28 to 33	1·077 to 1·092
Common ale - -. - -	25 to 27	1·070 to 1·073
Ditto ditto - - - -	21	1·058
Porter, common sort - -	18	1·050
Ditto, double - - - -	20	1·055
Ditto, brown stout - - -	23	1·064
Ditto, best brown stout - -	26	1·072
Common small beer - - -	6	1·014
Good table beer - - - -	12 to 14	1·033 to 1·039

Of Returns or Malt Residuums.— When small beer is brewed after ale or porter, only one mash is to be made; but where this is not done, there may be two mashes, in order to economize malt to the utmost. We may let on the water at 160° or 165°, in any convenient quantity, infuse for an hour or thereby, then run it off, and pump into the copper, putting some hops into it, and causing it to boil for an instant; when it may be transferred to the cooler. A second mash or return may be made in the same manner, but at a heat 5° lower; and then disposed of in the boiler with some hops, which may remain in the copper during the night at a scalding heat, and may be discharged into the cooler in the morning. These two returns are to be let down into the under-back immediately before the next brewing, and thence heated in the copper for the next

mashing of fresh malt, instead of hot water, commonly called *liquor*, in the breweries. But allowance must be made, in the calculation of the worts, for the quantity of fermentable matter in these two returns. The nett aggregate saving is estimated from the gravity of the return taken when cold in the cooler. A slight economy is also made in the extra boiling of the used hops. The lapse of a day or two between the consecutive brewings is no objection to the method of *returns*, because they are too weak in saccharine matter to run any risk of fermentation.

In conclusion, it may be remarked that Mr. Richardson somewhat underrates the gravity of porter, which is now seldom under 20lbs. per barrel. The criterion for transferring from the gyle-tun to the cleansing butts is the attenuation caused by the production of alcohol in the beer: when that has fallen to 10lbs. or 11lbs., which it usually does in 48 hours, the cleansing process is commenced. The heat is at this time generally 75°, if it was pitched at 65°; for the heat and the attenuation go hand in hand.

About thirty years ago, it was customary for the London brewers of porter to keep immense stocks of it for eighteen months or two years, with the view of improving its quality. The beer was pumped from the cleansing butts into store-vats, holding from twenty to twenty-five gyles or brewings of several hundred barrels each. The store-vats had commonly a capacity of 5000 or 6000 barrels; and a few were double, and one was treble, this size. The porter, during its long repose in these vats, became fine, and by obscure fermentation its saccharine mucilage was nearly all converted into vinous liquor, and dissipated in carbonic acid. Its hop-bitter was also in a great degree decomposed. *Good hard beer* was the boast of the day. This was sometimes softened by the publican, by the addition of some mild new-brewed beer. Of late years, the taste of the metropolis has undergone such a complete revolution in this respect, that nothing but the mildest porter will now go down. Hence, six weeks is a long period for beer to be kept in London; and much of it is drunk when only a fortnight old. Ale is for the same reason come greatly into vogue; and the two greatest porter houses, Messrs. Barclay, Perkins, & Co., and Truman, Hanbury, & Co., have become extensive and successful brewers of mild ale, to please the changed palate of their customers.

We shall add a few observations upon the brewing of Scotch ale. This beverage is characterized by its pale amber color, and its mild balsamic flavor. The bitterness of the hop is so mellowed with the malt as not to predominate. The ale of Preston Pans is, in fact, the best substitute for wine which barley has hitherto produced. The low temperature at which the Scotch brewer pitches his fermenting tun restricts his labors to the colder months of the year. He does nothing during four of the summer months. He is extremely nice in selecting his malt and hops; the former being made from the best English barley, and the latter being the growth of Farnham or East Kent. The yeast is carefully looked after, and measured into the fermenting tun in the proportion of one gallon to 240 gallons of wort.

Only one mash is made by the Scotch ale brewer, and that pretty strong; but the malt is exhausted by eight or ten successive sprinklings of liquor (hot water) over the goods (malt), which are termed in the vernacular tongue, *sparges*. These waterings percolate through the malt on the mash-tun bottom, and extract as much of the saccharine matter as may be sufficient for the brewing. By this simple method much higher specific gravities may be obtained than would be practicable by a second mash. With malt, the infusion or saccharine fermentation of the *diastase* is finished with the first mash; and nothing remains but to wash away from the goods the matter which that process has rendered soluble. It will be found on trial that 20 barrels of wort drawn from a certain quantity of malt, by two successive mashings, will not be so rich in fermentable matter as 20 barrels extracted by ten successive sparges of two barrels each. The grains always remain soaked with wort like that just drawn off, and the total residual quantity of three fourths of a barrel for every quarter of malt. The gravity of this residual wort will on the first plan be equal to that of the second mash; but on the second plan, it will be equal only to that of the tenth sparge, and will be more attenuated in a very high geometrical ratio. The only serious objection to the sparging system is the loss of time by the successive drainages. A mash-tun with a steam jacket promises to suit the sparging system well; as it would keep up a uniform temperature in the goods, without requiring them to be sparged with very hot liquor.

The first part of the Scotch process seems of doubtful economy; for the mash liquor is heated so high as 180°. After mashing for about half an hour, or till every particle of the malt is thoroughly drenched, the tun is covered, and the mixture left to infuse about three hours; it is then drained off into the under-back, or preferably into the wort copper.

After this wort is run off, a quantity of liquor (water), at 180° of heat, is sprinkled uniformly over the surface of the malt; being first dashed on a perforated circular bowl, suspended horizontally over the mash-tun, wherefrom it descends like a shower

upon the whole of the goods. The percolating wort is allowed to flow off, by three more small stopcocks round the circumference of the mash-tun, to ensure the equal fusion of the liquor.

The first sparge being run off in the course of twenty minutes, another similar is affused; and thus in succession till the whole of the drainage, when mixed with first mash-wort, constitutes the density adapted to the quality of the ale. Thus, strong worts are prepared, and the malt is exhausted either for table beer, or fo *return*, as pointed out above. The last sparges are made 5° or 6° cooler than first.

The quantity of hops seldom exceeds four pounds to the quarter of malt. The man of boiling the worts is the same as that above described; but the conduct of the mentation is peculiar. The heat is pitched at 50°, and the fermentation continues fl a fortnight to three weeks. Were three brewings made in the week, seven or ei working tuns would thus be in constant action; and, as they are usually in one ro and some of them at an *elevation* of temperature of 15°, the apartment must be pitious to fermentation, however low its heat may be at the commencement. No n yeast is used than is indispensable; if a little more be needed, it is made effective rousing up the tuns twice a day from the bottom.

When the progress of the attenuation becomes so slack as not to exceed half a po in the day, it is prudent to cleanse, otherwise the top-barm might re-enter the body of beer, and it would become *yeast-bitten*. When the ale is cleansed, the head, which not been disturbed for some days, is allowed to float on the surface till the whole of *then* pure ale is drawn off into the casks. This top is regarded as a sufficient preserva against the contact of the atmosphere. The Scotch do not skim their tuns, as the I don ale brewers commonly do. The Scotch ale, when so cleansed, does not requir be set upon close stillions. It throws off little or no yeast, because the fermenta was nearly finished in the tun. The strength of the best Scotch ale ranges between and 44 pounds to the barrel; or it has a specific gravity of from 1·088 to 1·122, accor to the price at which it is sold. In a good fermentation, seldom more than a fourt the original gravity of the wort remains at the period of the cleansing. Between third and one fourth is the usual degree of attenuation. Scotch ale soon becomes and is seldom racked for the home market. The following table will show the prog of fermentation in a brewing of good Scotch ale:

$$20 \text{ barrels of mash-worts of } 42\tfrac{1}{2} \text{ pounds gravity} = 860·6$$
$$20 \quad — \quad \text{returns} \quad 6\tfrac{1}{10} \quad\quad = 122$$

$$12) 982·6$$

pounds weight of extract per quarter of malt = 81

Fermentation :—

March 24. pitched the tun at 51°: yeast 4 gallons.

	Temp.	Gravity.
25.	52°	41 pounds.
28.	56°	39
30.	60°	34
April 1.	62°	32
4.	65°	29 added 1 lb. of yeast.
5.	66°	25
6.	67°	23
7.	67°	20
8.	66°	18
9.	66°	15
10.	64°	14·5 cleansed. *

The following table shows the origin and the result of fermentation, in a numbe practical experiments :—

Original Gravity of the Worts.	Lbs. per Barrel of Saccharine Matter.	Specific Gravity of the Ale.	Lbs. per Barrel of Saccharine Matter.	Attenuation, or charum decompo
1·0950	88·75	1·0500	40·25	0·478
1·0918	85·62	1·0420	38·42	0·552
1·0829	78·125	1·0205	16·87	0·787
1·0862	80·625	1·0236	20·00	0·757
1·0780	73·75	1·0280	24·25	0·698
1·0700	65·00	1·0285	25·00	0·615
1·1002	93·75	1·0400	36·25	0·613

* BREWING (Society for diffusing Useful Knowledge), p. 156.

Fermentation Table — *continued.*

Original Gravity of the Worts.	Lbs. per Barrel of Saccharine Matter.	Specific Gravity of the Ale.	Lbs. per Barrel of Saccharine Matter.	Attenuation, or Saccharum decomposed.
1·1025	95·93	1·0420	38·42	0·600
1·0978	91·56	1·0307	27·00	0·705
1·0956	89·37	1·0358	32·19	0·640
1·1130	105·82	1·0352	31·87	0·661
1·1092	102·187	1·0302	26·75	0·605
1·1171	110·00	1·0400	36·25	0·669
1·1030	96·40	1·0271	23·42·	0·757
1·0660	61·25	1·0214	17·80	0·709

The second column here does not represent, I believe, the solid extract, but the pasty extract obtained as the basis of Mr. Allen's saccharometer, and therefore each of its numbers is somewhat too high. The last column, also, must be in some measure erroneous, on account of the quantity of alcohol dissipated during the process of fermentation. It must be likewise incorrect, because the density due to the saccharine matter will be partly counteracted, by the effect of the alcohol present in the fermented liquor. In fact, the attenuation does not correspond to the strength of the wort; being greatest in the third brewing, and smallest in the first. The quantity of yeast for the above ale brewings in the table was, upon an average, one gallon for 108 gallons; but it varied with its quality, and with the state of the weather, which, when warm, permits much less to be used with propriety.

The good quality of the malt, and the right management of the mashing, may be tested by the quantity of saccharine matter contained in the successively drawn worts. With this view, an aliquot portion of each of them should be evaporated by a safety-bath heat to a nearly concrete consistence, and then mixed with twice its volume of strong spirit of wine. The truly saccharine substance will be dissolved, while the starch and other matters will be separated; after which the proportions of each may be determined by filtration and evaporation. Or an equally correct, and much more expeditious method of arriving at the same result would be, after agitating the viscid extract with the alcohol in a tall glass cylinder, to allow the insoluble fecula to subside, and then to determine the specific gravity of the supernatant liquid by a hydrometer. The additional density which the alcohol has acquired will indicate the quantity of malt sugar which it has received. The following table, constructed by me, at the request of Henry Warburton, Esq., M. P., chairman of the Molasses Committee of the House of Commons in 1830, will show the brewer the principle of this important inquiry. It exhibits the quantity in grains weight of sugar requisite to raise the specific gravity of a gallon of spirit of different densities to the gravity of water = 1·000 :

Specific Gravity of Spirit.	Grains; Weight of Sugar in the Gallon Imperial.
0·995	980
0·990	1·890
0·985	2·800
0·980	3·710
0·975	4·690
0·970	5·600
0·965	6·650
0·960	7·070
0·955	8·400
0·950	9·310

The immediate purpose of this table was to show the effect of saccharine matter in disguising the presence or amount of alcohol in the weak feints of the distiller. But a similar table might easily be constructed, in which, taking a uniform quantity of alcohol of 0·825, for example, the quantity of sugar in any wort-extract would be shown by the increase of specific gravity which the alcohol received from agitation with a certain weight of the wort, inspissated to a nearly solid consistence by a safety-pan, made on the principle of my patent sugar-pan. (See SUGAR.) Thus, the normal quantities being 1000 grain measures of alcohol, and 100 grains by weight of inspissated mash-extract, the hydrometer would at once indicate, by help of the table, first, the quantity per cent. of truly saccharine matter, and next, by subtraction, that of farinaceous matter present in it.

Plan, Machinery, and Utensils of a great Brewery.—*Figs.* 103 and 104 represent the arrangement of the utensils and machinery in a porter brewery on the largest scale; in which, however, it must be observed that the elevation *fig.* 103 is in a great degree imaginary as to the plane upon which it is taken; but the different vessels are arranged so as

to explain their uses most readily, and at the same time to preserve, as nearly as the relative positions which are usually assigned to each in works of this nature.
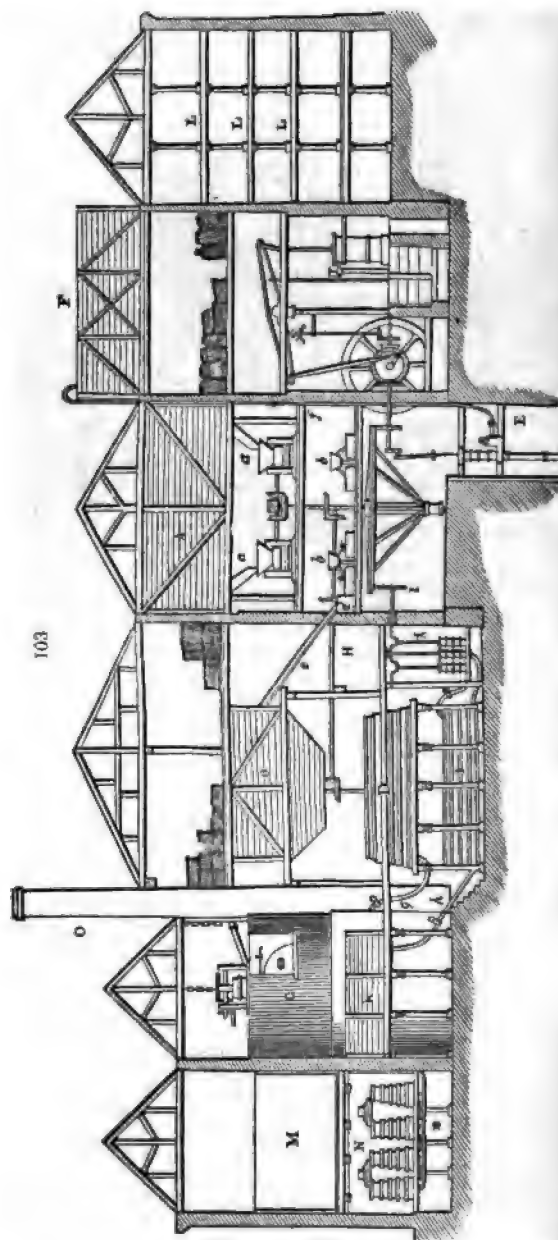
The malt for the supply of the brewery is stored in vast granaries or malt-lofts situated in the upper part of the buildings. Of these, I have been able to r only one, at A, *fig.* 103 : the others, which are supposed to be on each side of it

ı this view. Immediately beneath the granary A, on the ground floor, is the
he upper story above it, are two pairs of rollers, *figs.* 101, 102, and 103, under
cruising or crushing the grains of the malt. In the floor beneath the rollers are
ones *b, b*, where the malt is sometimes ground, instead of being merely bruised
; between the rollers, under *a, a.*

ılt, when prepared, is conveyed by a trough into a chest *d*, to the right of *b*,
h it can be elevated by the action of a spiral screw, *fig.* 105, enclosed in the
be *e*, into the large chest or bin B, for holding ground malt, situated imme-
er the mash-tun D. The malt is reserved in this bin till wanted, and it is
own into the mashing-tun, where the extract is obtained by hot water supplied
copper G, seen to the right of B.

ıter for the service of the brewery is obtained from the well F, seen beneath the
: left, by a lifting pump worked by the steam engine; and the forcing-pipe *f*
mp conveys the water up to the large reservoir or water-back F, placed at the
: engine-house. From this cistern, iron pipes are laid to the copper G (on the
l side of the figure), as also to every part of the establishment where cold water
ınted for cleaning and washing the vessels. The copper G can be filled with
r by merely turning a cock; and the water, when boiled therein, is conveyed
ıe *g* into the bottom of the mash-tun D. It is introduced beneath a false bot-
ı which the malt lies, and, rising up through the holes in the false bottom, it
he saccharine matter from the malt; a greater or less time being allowed for the
according to circumstances. The instant the water is drawn off from the copper,
er must be let into it, in order to be ready for boiling the second mashing; be-
copper must not be left empty for a moment, otherwise the intense heat of the
l destroy its bottom. For the convenience of thus letting down at once as much
will fill the lower part of the copper, a pan or second boiler is placed over the
copper, as seen in *fig.* 103; and the steam rising from the copper communi-
ınsiderable degree of heat to the contents of the pan, without any expense of
.is will be more minutely explained hereafter. (*See fig.* 107.)

the process of mashing, the malt is agitated in the mash-tun so as to expose
t to the action of the water. This is done by a mechanism contained within
tun, which is put in motion by a horizontal shaft above it, H, leading from the
.e mash machine is shown separately in *fig.* 106. When the operation of mash-
shed, the wort or extract is drained down from the malt into the vessel I, called
-back, immediately below the mash-tun, of like dimensions, and situated always
r level, for which reason it has received this name. Here the wort does not re-
:er than is necessary to drain off the whole of it from the tun above. It is then
p by the three-barrelled pump *k*, into the pan upon the top of the copper, by a
h cannot be seen in this section. The wort remains in the pan until the water
ıceeding mashes is discharged from the copper. But this delay is no loss of
ıuse the heat of the copper, and the steam arising from it, prepare the wort,
l become cooler, for boiling. The instant the copper is emptied, the first wort
n from the pan into the copper, and the second wort is pumped up from the
.k into the upper pan. The proper proportion of hops is thrown into the cop-
gh the near hole, and then the door is shut down, and screwed fast, to keep in
, and cause it to rise up through pipes into the pan. It is thus forced to blow
;h the wort in the pan, and communicates so much heat to it, or water, called *li-*
he brewers, that either is brought near to the boiling point. The different worts
ach other through all the different vessels with the greatest regularity, so that
ıo loss of time, but every part of the apparatus is constantly employed. When
tion has continued a sufficient period to coagulate the grosser part of the extract,
aporate part of the water, the contents of the copper are run off through a large
the *jack-back* K, below G, which is a vessel of sufficient dimensions to contain
ovided with a bottom of cast-iron plates, perforated with small holes, through
: wort drains and leaves the hops. The hot wort is drawn off from the jack-
ugh the pipe *h* by the three-barrelled pump, which throws it up to the coolers
his pump being made with different pipes and cocks of communication, to serve
ırposes of the brewery except that of raising the cold water from the well. The
L, L, are very shallow vessels, built over one another in several stages: and that
e building in which they are contained is built with lattice-work or shutter flaps,
es, to admit free currents of air. When the wort is sufficiently cooled to be put to
ermentation, it is conducted in pipes from all the different coolers to the large
g vessel or gyle-tun M, which, with another similar vessel behind it, is of suffi-
ıeity to contain all the beer of one day's brewings.

ver the first fermentation is concluded, the beer is drawn off from the great fer-
ressel M, into the small fermenting casks or cleansing vessels N, of which there
at number in the brewery. They are placed four together, and to each four a com-

mon spout is provided to carry off the yeast, and conduct it into the trough beneath. In these cleansing vessels the beer remains till the fermentation is and it is then put into the store-vats, which are casks or tuns of an immense

it is kept till want finally drawn off in and sent away from the The store-vats are not in the figure : they are shape, and of differ sions, from fifteen to diameter, and usually to twenty feet in de steam-engine which p machine in motion i in its place, on the the figure. On the large fly-wheel is a be wheel, which turns milar wheel upon the horizontal shaft, whi from the engine-hou great horse-wheel, se by means of a spur-v horse-wheel drives all for the mill-stones *b* the horizontal axis w the three-barrelled pu rollers *a, a,* are turned wheel upon the upper axis of the horse-whe prolonged for that pu the horizontal shaft mashing engine, is d pair of bevel wheels. likewise a sack-tackle not represented. It is for drawing up the sa from the court-yard to part of the building, sacks are wheeled on the malt-loft A, and t of the sacks are discha

The horse-wheel is be driven by horses if the steam-engine but these engines are to such perfection tha seldom any recourse of needed.

Fig. 104 is a re of the *fermenting he* brewery of Messrs. and Company, Chisw London, which is one complete in its arra the world : it was erec plan of Mr. Richardso ducts the brewing at t The whole of *fig.* 1 considered as devoted object as the large v the casks N, *fig.* 103. *r r* is the pipe which the different coolers the wort to the great

vessels or squares M, of which there are two, one behind the other ; *f f* represe the great pipe which conveys all the water from the well E, *fig.* 103, up to the w
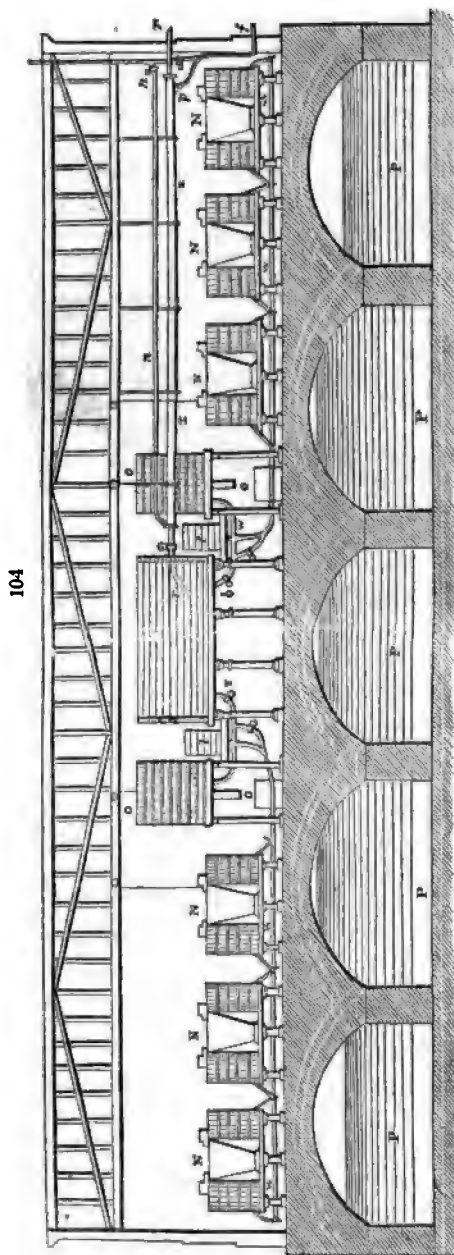
r. This pipe is conducted purposely up the wall of the fermenting-house, *fig.* 104, and has a cock in it, near *r*, to stop the passage. Just beneath this passage a branch-pipe *p* proceeds, and enters a large pipe *x x*, which has the former pipe *r* withinside of it. From the end of the pipe *x*, nearest to the squares M, another branch *n n* proceeds, and returns to the original pipe *f*, with a cock to regulate it. The object of this arrangement is to make all, or any part, of the cold water flow through the pipe *x x*, which surrounds the pipe *r*, formed only of thin copper, and thus cool the wort passing through the pipe *x*, until it is found by the thermometer to have the exact temperature which is desirable before it is put to ferment in the great square M. By means of the cocks at *n* and *p*, the quantity of cold water passing over the surface of the pipe *r* can be regulated at pleasure, whereby the heat of the wort, when it enters into the square, may be adjusted within half a degree.

When the first fermentation in the squares M M is finished, the beer is drawn off from them by pipes marked *v*, and conducted by its branches w w w, to the different rows of fermenting-tuns, marked N N, which occupy the greater part of the building. In the hollow between every two rows are placed large troughs, to contain the yeast which they throw off. The figure shows that the small tuns are all placed on a lower level than the bottom of the great vessels M, so that the beer will flow into them, and, by hy-drostatic equilibrium, will fill them to the same level. When they are filled, the com-munication-cock is shut; but, as the working off the yeast diminishes the quantity of beer in each vessel, it is necessary to replenish them from time to time. For this purpose, the two large vats o o are filled from the great squares M M, before any beer is drawn off into the small casks N, and this quantity of beer is reserved at the higher level for filling up. The two vessels o o are, in reality, situated between the two squares M M; but I have been obliged to place them thus in the section, in order that they may be seen. Near each filling-up tun o is a small cistern *t* communicating with the tun o by a pipe which is closed by a float-valve. The small cisterns *t* are always in communication with the pipes which lead to the small fermenting vessels N; and there-fore the surface of the beer in all the tuns, and in the cisterns, will always be at the same level; and as this level subsides by the working off of the yeast from the tuns, the float sinks and opens the valve, so as to admit a sufficiency of beer from the filling-up tuns o, to restore the surfaces of the beer in all the tuns, and also in the cistern *t*, to the original level. In order to carry off the yeast which is produced by the fermentation of the beer in the tuns o o, a conical iron dish or funnel is made to float upon the surface of the beer which they contain; and from the centre of this funnel a pipe, o, descends, and passes through the bottom of the tun, being packed with a collar of leather, so as to be water-tight; at the same time that it is at liberty to slide down, as the surface of the beer descends in the tun. The yeast flows over the edge of this funnel-shaped dish, and is conveyed down the pipe to a trough beneath.

Beneath the fermenting-house are large arched vaults, r, built with stone, and lined with stucco. Into these the beer is let down in casks when sufficiently fermented, and is kept in store till wanted. These vaults are used at Mr. Whitbread's brewery, instead of the great store-vats of which we have before spoken, and are in some respects pre-ferable, because they preserve a great equality of temperature, being beneath the surface of the earth.

The malt-rollers, or machines for bruising the grains of the malt, *figs.* 101, 102, have been already described. The malt is shot down from A, *fig.* 103, the malt-loft, into the hopper; and from this it is let out gradually through a sluice or sliding shuttle, *a, fig.* 103, and falls between the rollers.

Fig. 105, is the screw by which the ground or bruised malt is raised up, or conveyed from one part of the brewery to another. K is an inclined box or trough, in the centre of which the axis of the screw H is placed; the spiral iron plate or worm, which is fixed projecting from the axis, and which forms the screw, is made very nearly to fill the inside of the box. By this means, when the screw is turned round by the wheels E F, or by any other means, it raises up the malt from the box *d*, and delivers it at the spout G.

This screw is equally applicable for conveying the malt horizontally in the trough K, slantingly; and similar machines are employed in various parts of breweries for con-veying the malt wherever the situation of the works requires.

Fig. 106, is the mashing-machine. *a a* is the tun, made of wood staves, hooped to-gether. In the centre of it rises a perpendicular shaft, *b*, which is turned slowly round by means of the bevelled wheels *t u* at the top. *c c* are two arms, projecting from that axis, and supporting the short vertical axis *d* of the spur-wheel *x*, which is turned by the spur-wheel *w*; so that, when the central axis *b* is made to revolve, it will carry the thick short axle *d* round the tun in a circle. That axle *d* is furnished with a number of arms, *e e*, which have blades placed obliquely to the plane of their

motion. When the axis is turned round, these arms agitate the malt in the tun, and give it a constant tendency to rise upward from the bottom.

The motion of the axle d is produced by a wheel, x, on the upper end of it, which is

105
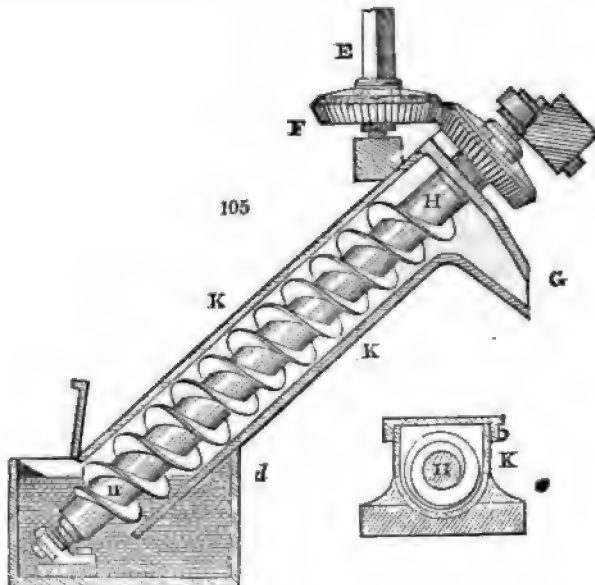
turned by a wheel, w, fastened on the middle of the tube b, which turns freely round upon its central axis. Upon a higher point of the same tube b is a bevel wheel, o, receiving motion from a bevel wheel, q, fixed upon the end of the horizontal axis a,

108
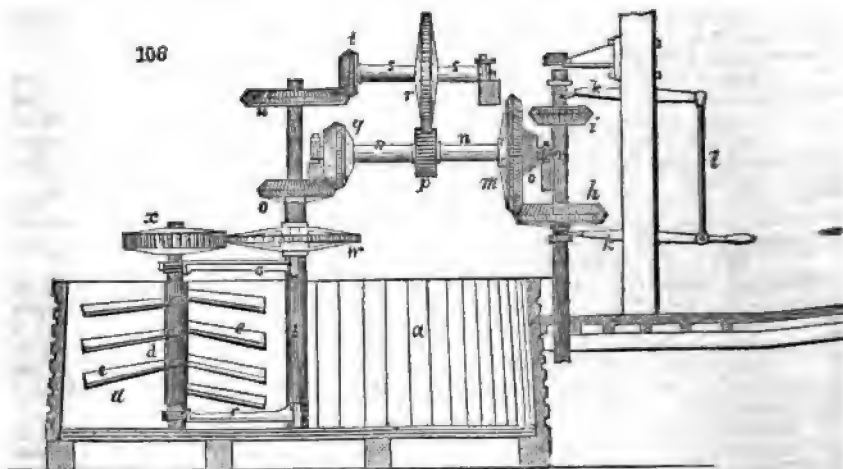
which gives motion to the whole machine. This same axis has a pinion, p, upon it, which gives motion to the wheel r, fixed near the middle of a horizontal axis which, at its left hand end, has a bevel pinion, t, working the wheel u, before mentioned. By these means, the rotation of the central axis b will be very slow compared with the motion of the axle d; for the latter will make seventeen or eighteen revolutions on its own axis in the same space of time that it will be carried once round the tun by the motion of the shaft b. At the beginning of the operation of mashing, the machine is made to turn with a slow motion; but, after having wetted all the malt by one revolution, it is driven quicker. For this purpose, the ascending shaft $f\,g$, which gives

motion to the machine, has two level wheels, $h\,i$, fixed upon a tube, $f\,g$, which is, fitted upon a central shaft. These wheels actuate the wheels m and o, upon the end of the horizontal shaft $n\,n$; but the distance between the two wheels h and i is such, that they cannot be engaged both at once with the wheels m and o; but the tube $f\,g$, to which they are fixed, is capable of sliding up and down on its central axis sufficiently to bring either wheel h or i into gear with its corresponding wheel o or m, upon the horizontal shaft; and as the diameters of $n\,o$, and $i\,m$, are of very different proportions, the velocity of the motion of the machine can be varied at pleasure, by using one or other. k and k are two levers, which are forked at their extremities, and embrace collars at the ends of the tube $f\,g$. These levers being united by a rod, l, the handle k gives the means of moving the tube $f\,g$, and its wheels $h\,i$, up or down, to throw either the one or the other wheel into gear.

The object of boiling the wort is not merely evaporation and concentration, but extraction, coagulation, and, finally, combination with the hops; purposes which are better accomplished in a deep confined copper, by a moderate heat, than in an open shallow pan with a quick fire. The copper, being incased above in brickwork, retains its digesting temperature much longer than the pan could do. The waste steam of the close kettle, moreover, can be economically employed in communicating heat to water or weak worts; whereas the exhalations from an open pan would prove a nuisance, and would need to be carried off by a hood. The boiling has a four-fold effect: 1. it concentrates the wort; 2. during the earlier stages of heating, it converts the starch into sugar, dextrine, and gum, by means of the diastase; 3. it extracts the substance of the hops diffused through the wort; 4. it coagulates the albuminous matter present in the grain, or precipitates it by means of the tannin of the hops.

The degree of evaporation is regulated by the nature of the wort, and the quality of the beer. Strong ale and stout for keeping, require more boiling than ordinary porter or table-beer brewed for immediate use. The proportion of the water carried off by evaporation is usually from a seventh to a sixth of the volume. The hops are introduced during the progress of the ebullition. They serve to give the beer not only a bitter aromatic taste, but also a keeping quality, or they counteract its natural tendency to become sour; an effect partly due to the precipitation of the albumen and starch, by their resinous and tanning constituents, and partly to the antifermentable properties of their lupuline, bitter principle, ethereous oil, and resin. In these respects, there is none of the bitter plants which can be substituted for hops with advantage. For strong beer, powerful fresh hops should be selected; for weaker beer, an older and weaker article will suffice.

The hops are either boiled with the whole body of the wort, or extracted with a portion of it; and this concentrated extract added to the rest. The stronger the hops are, the longer time they require for extraction of their virtues; for strong hops, an hour and a half or two hours boiling may be proper; for a weaker sort, half an hour or an hour may be sufficient; but it is never advisable to push this process too far, lest a disagreeable bitterness, without aroma, be imparted to the beer. In our breweries, it is the practice to boil the hops with a part of the wort, and to filter the decoction through a strainer, called the *jack hop-back*. The proportion of hops to malt is very various; but, in general, from a pound and a quarter to a pound and a half of the former are taken for 100 lbs. of the latter in making good table-beer. For porter and strong ale, 2 pounds of hops are used, or even more; for instance, one pound of hops to a bushel of malt, if the beer be destined for the consumption of India.

During the boiling of the two ingredients, much coagulated albuminous matter, in various states of combination, makes its appearance in the liquid, constituting what is called the *breaking or curdling of the wort*, when numerous minute flocks are seen floating in it. The resinous, bitter, and oily-ethereous principles of the hops combine with the sugar and gum, or dextrine of the wort; but for this effect they require time and heat; showing that the boil is not a process of mere evaporation, but one of chemical reaction. A yellowish-green pellicle of hop-oil and resin appears upon the surface of the boiling wort, in a somewhat frothy form: when this disappears, the boiling is presumed to be completed, and the beer is strained off into the cooler. The residuary hops may be pressed and used for an inferior quality of beer; or they may be boiled with fresh wort, and be added to the next brewing charge.

Fig. 107, 108, represent the copper of a London brewery. *Fig.* 107 is a vertical section; *fig.* 108, a ground-plan of the fire-grate and flue, upon a smaller scale: a is the close copper kettle, having its bottom convex within; b is the open pan placed upon its top. From the upper part of the copper, a wide tube, c, ascends, to carry off the steam generated during the ebullition of the wort, which is conducted through four downwards-slanting tubes, $d\,d$ (two only are visible in this section), into the liquor of the pan b, in order to warm its contents. A vertical iron shaft or spindle, e, passes down through the tube c, nearly to the bottom of the copper, and is there mounted with an iron arm, called a

rouser, which carries round a chain hung in loops, to prevent the hops from adhering to the bottom of the boiler. Three bent stays, *f*, are stretched across the interior, to support the shaft by a collet at their middle junction. The shaft carries at its upper end a bevel
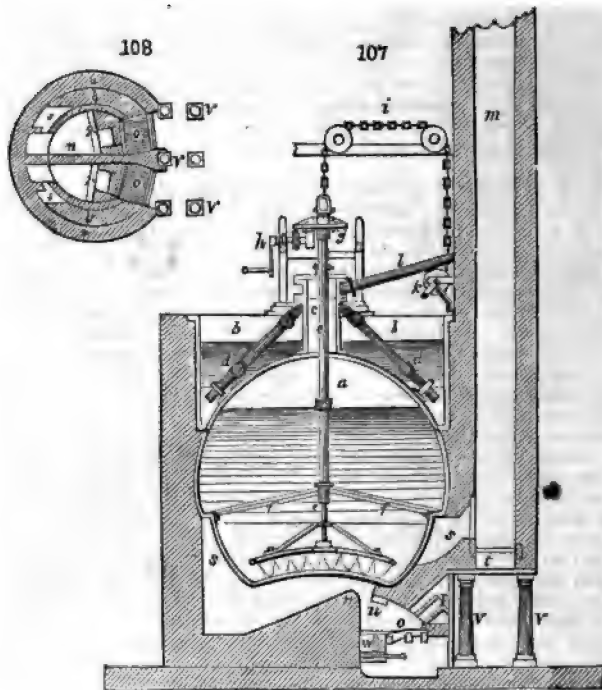

wheel, *g*, working into a bevel pinion upon the axis *h*, which may be turned either by power or by hand. The *rouser* shaft may be lifted by means of the chain *i*, which, going over two pulleys, has its end passed round the wheel and axle *k*, and is turned by a winch : *l* is a tube for conveying the waste steam into the chimney *m*.

The heat is applied as follows :—For heating the colossal coppers of the London breweries, two separate fires are required, which are separated by a narrow wall of brickwork, *n*, *figs*. 107, 108. The dotted circle *a′ a′* indicates the largest circumference of the copper, and *b′ b′* its bottom ; *o o* are the grates upon which the coals are thrown, not through folding doors (as of old), but through a short slanting iron hopper, shown at *p*, *fig*. 107, built in the wall, and kept constantly filled with the fuel, in order to exclude the air. Thus the lower stratum of coals gets ignited before it reaches the grate. Above the hopper *p*, a narrow channel is provided for the admission of atmospherical air, in such quantity merely as may be requisite to complete the combustion of the smoke of the coals. Behind each grate there is a fire-bridge, *r*, which reflects the flame upwards, and causes it to play upon the bottom of the copper. The burnt air then passes round the copper in a semicircular flue, *s s*, from which it flows off into the chimney *m*, on whose under end a sliding damper-plate, *t*, is placed for tempering the draught When cold air is admitted at this orifice, the combustion of the fuel is immediately checked. There is, besides, another slide-plate at the entrance of the slanting flue into the vertical chimney, for regulating the play of the flame under and around the copper. If the plate *t* be opened, and the other plate shut, the power of the fire is suspended, as it ought to be, at the time of emptying the copper. Immediately over the grate is a brick arch, *u*, to protect the front edge of the copper from the first impulsion of the flame. The chimney is supported upon iron pillars, *v*, *v* ; *w* is a cavity closed with a slide-plate, through which the ashes may be taken out from behind, by means of a long iron hook.

Fig. 109 represents one of the sluice-cocks, which are used to make the communications of the pipes with the pumps, or other parts of the brewery. *b b* represents the pipe in which the cock is placed. The two parts of this pipe are screwed to the side of a box, *c c*, in which a slider, A, rises and falls, and intercepts, at pleasure, the passage of the pipe. The slider is moved by the rod *a*. This passes through a stuffing-

box, in the top of the box which contains the slider, and has the rack b fastened to it. The rack is moved by a pinion fixed upon the axis of a handle e, and the rack and pinion are contained in a frame d, which is supported by two pillars. The frame contains a small roller behind the rack, which bears it up towards the pinion, and keeps its teeth up to the teeth of the pinion. The slider A is made to fit accurately against the internal surface of the box c, and to bear against this surface by the pressure of a spring, so as to make a perfectly close fitting.

Fig. 110 is a small cock to be placed in the side of the great store vats, for the purpose of drawing off a small quantity of beer, to taste and try its quality. A is a
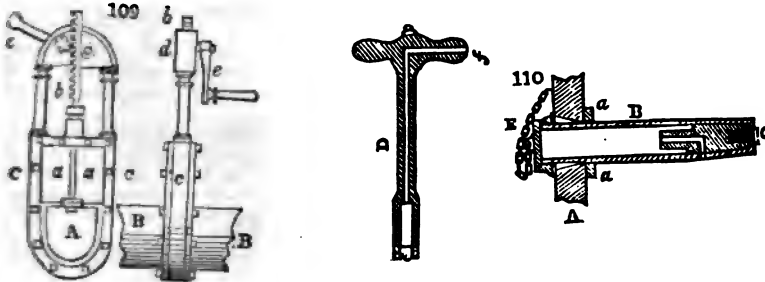
part of the stave or thickness of the great store vat; into this the tube B of the cock is fitted, and is held tight in its place by a nut, a a, screwed on withinside. At the other end of the tube B, a plug, c, is fitted, by grinding it into a cone, and it is kept in by a screw. This plug has a hole up the centre of it, and from this a hole proceeds sidewise, and corresponds with a hole made through the side of the tube when the cock is open; but when the plug c is turned round, the hole will not coincide; and then the cock will be shut. D is the handle or key of the cock, by which its plug is turned to open or shut it: this handle is put up the bore of the tube (the cover E being first unscrewed and removed), and the end of it is adapted to fit the end of the plug of the cock. The handle has a tube or passage bored up it, to convey the beer away from the cock when it is opened, and from this the passage f, through the handle, leads, to draw the beer into a glass or tumbler. The hole in the side of the plug is so arranged, that, when the handle is turned into a perpendicular direction, with the passage f downwards, the cock will be open. The intention of this contrivance is, that there shall be no considerable projection beyond the surface of the tun; because it sometimes happens that a great hoop of the tun breaks, and, falling down, its great weight would strike out any cock which had a projection; and, if this happened in the night, much beer might be lost before it was discovered. The cock above described, being almost wholly within-side, and having scarcely any projection beyond the outside surface of the tun, is secure from this accident.

Fig. 111 is a small contrivance of a vent peg, to be screwed into the head of a common cask when the beer is to be drawn off from it, and it is necessary to admit some air to allow the beer to flow. A A represents a portion of the head of the cask into which the tube B is screwed. The top of this tube is surrounded by a small cup, from which project the two small handles c c, by which the peg is turned round to screw it into the cask. The cup round the other part of the tube is filled with water; into this a small cup, D, is inverted; in consequence, the air can gain admission into the cask when the pressure within is so far diminished, that the air will bubble up through the water, and enter beneath the small cup D.

The most efficient substance for fining beer hitherto discovered is isinglass, which is prepared by solution in vinegar or old stale beer, and this solution is afterwards reduced with thin mild beer generally brewed for the purpose, in all large establishments, from a new or return wort. It must next be passed through a fine hair sieve, by means of rubbing it down with a hard hair-brush, and brought to the proper consistency by thin mild beer. If properly made, it will be clear, transparent, and free from feculencies. Finings serve excellently to remove any extraneous matter that may be found floating in the beer, and thus changes it from bright to brilliant. The common quantity used is from a pint to a quart per barrel, according to the nature of the beer.

To ascertain whether the beer is in a fit state for fining, put it into a long glass cylindric vessel, and add to it a teaspoonful, or thereby, of the fining; then give the mixture a good shake, by turning the vessel up and down, after closing its mouth with

the palm of the hand. ·If the beer has been well brewed, its aptitude to become bright will be soon shown by the mixture getting thick and curdy; a bright portion will generally show itself at the bottom or middle; after which the finings will gradually mount to the top, taking up all the impurities along with them, till the whole becomes brilliant. Some have said that the finings should carry the impurities down to the bottom; but this, according to Mr. Black,[*] takes place only with stubborn beer, which would not become thoroughly bright with any quantity of finings which could be introduced. Finings have usually a specific gravity of from 1·010 to 1·016, and, when added to beer in a fit condition for fining, invariably go to the top, and not to the bottom. In fining beer in a barrel laid on its side, if the finings do not make their appearance at the bung-hole, the beer will not become bright. The isinglass must not be dissolved with heat, nor in hot water.

Beer brewed from imperfectly malted grain, or from a mixture of malt and raw corn, gives a fermentation quite different in flavor from that of beer from sound malt. The nose is, in fact, the best guide to the experienced brewer for ascertaining whether his process is going on well or ill.

Ropiness is a morbid state of beer, which is best remedied, according to Mr. Black, by putting the beer into a vat with a false bottom, and adding, per barrel, 4 or 5 pounds of hops, taken gradually away after the first boilings of the worts; and to them may be added about half a pound per barrel of mustard-seed. Rouse the beer as the hops are gradually introduced, and, in some months, the ropiness will be perfectly cured. The beer should be drawn off from below the false bottom.

For theoretical views, see FERMENTATION; and for wort-cooling apparatus, see REFRIGERATOR.

BEET-ROOT SUGAR. See SUGAR.

BELL-METAL, an alloy of copper and tin. See COPPER.

BELLOWS. See METALLURGY.

BEN OIL. See OIL OF BEN.

BENGAL STRIPES. Ginghams; a kind of cotton cloth woven with colored stripes.

BENJAMIN or BENZOIN. (*Benjoin*, Fr.; *Benzöe*, Germ.) A species of resin used chiefly in perfumery. It is extracted by incision from the trunk and branches of the *styrax benzoin*, which grows in Java, Sumatra, Santa Fé, and in the kingdom of Siam. The plant belongs to the decandria monogynia of Linnæus, and the natural family of the ebenaceæ. It hardens readily in the air, and comes to us in brittle masses, whose fracture presents a mixture of red, brown, and white grains of various sizes, which, when white, and of a certain shape, have been called *amygdaloid*, from their resemblance to almonds. The *sorted* benzoin is, on the other hand, very impure.

The fracture of benzoin is conchoidal, and its lustre greasy: its specific gravity varies from 1·063 to 1·092. It has an agreeable smell, somewhat like vanilla, which is most manifest when it is ground. It enters into fusion at a gentle heat, and then exhales a white smoke, which may be condensed into the acicular crystals of benzoic acid, of which it contains 18 parts in the hundred. Stoltze recommends the following process for extracting the acid. The resin is to be dissolved in 3 parts of alcohol, the solution is to be introduced into a retort, and a solution of carbonate of soda dissolved in dilute alcohol is to be gradually added to it, till the free acid be neutralized; and then a bulk of water equal to double the weight of the benzoin is to be poured in. The alcohol being drawn off by distillation, the remaining liquor contains the acid, and the resin floating upon it may be skimmed off and washed, when its weight will be found to amount to about 80 per cent. of the raw material. The benzoin contains traces of a volatile oil, and a substance soluble in water, at least through the agency of carbonate of potash. Ether does not dissolve benzoin completely. The fat and volatile oils dissolve very little of it.

Unverdorben has found in benzoin, besides benzoic acid, and a little volatile oil, no less than three different kinds of resin, none of which has, however, been turned as yet to any use in the arts.

Benzoin is of great use in perfumery, as it enters into a number of preparations; among which may be mentioned fumigating pastilles, fumigating cloves (called also nails), *poudre à la maréchale*, &c. The alcoholic tincture, mixed with water, forms *virginal* milk. Benzoin enters also into the composition of certain varnishes employed for snuff-boxes and walking-sticks, in order to give these objects an agreeable smell when they become heated in the hand. It is likewise added to the spirituous solution of isinglass with which the best court plaster is made.

BERLIN BLUE. Prussian blue. See BLUE.

BERRIES OF AVIGNON, *und Persian Berries*. (*Graines d'Avignon*, Fr.; *Gelbbeeren*, Germ.) A yellowish dye-drug, the fruit of the *rhamnus infectorius*, a plant

[*] Treatise on Brewing, 8vo, p. 68.

cultivated in Provence, Languedoc, and Dauphiné, for the sake of its berries, which are plucked before they are ripe, while they have a greenish hue. Another variety comes from Persia, whence its trivial name: it is larger than the French kind, and has superior properties. The principal substances contained in these berries are, 1. A coloring matter, which is united with a matter insoluble in ether, little soluble in concentrated alcohol, and very soluble in water: it appears to be volatile. 2. A matter remarkable for its bitterness, which is soluble in water and alcohol. 3. A third principle, in small quantity. A decoction of one part of the Avignon or Persian berry in ten of water affords a brown-yellow liquor bordering upon green, having the smell of a vegetable extract, and a slightly bitter taste.

With gelatine that decoction gives, after some time, a slight precipitate,—

—	alkalis - - - - - -	a yellow hue,
—	acids - - - - - - -	a slight muddiness,
—	lime-water - - - - -	a greenish-yellow tint,
—	alum - - - - - - -	a yellow color,
—	red sulphate of iron - - -	an olive-green color,
—	sulphate of copper - - -	an olive color,
—	proto-muriate of tin - -	a greenish yellow with a slight precipitate. (See CALICO PRINTING.)

BERYL. A beautiful mineral or gem, of moderate price, usually of a green color of various shades, passing into honey-yellow and sky blue.

BEZOAR. The name of certain concretions found in the stomachs of animals, to which many fanciful virtues were formerly ascribed. They are interesting only to the chemical pathologist.

BILE. (*Bile*, Fr.; *galle*, Germ.) The secreted liquor of the liver in animals. For an account of the uses of animal bile in the arts, see GALL.

BIRDLIME. (*Glu*, Fr.; *Vogelleim*, Germ.) The best birdlime may be made from the middle bark of the holly, boiled seven or eight hours in water, till it is soft and tender, then laid by heaps in pits under ground, covered with stones after the water is drained from it. There it must be left during two or three weeks, to ferment in the summer season, and watered if necessary, till it passes into a mucilaginous state. It is then to be pounded in a mortar to a paste, washed in running water, and kneaded till it be free from extraneous matters. It is next left for four or five days in earthen vessels to ferment and purify itself, when it is fit for use. Birdlime may be made by the same process from the mistletoe (*viburnum lantana*), young shoots of elder, and the barks of other vegetables, as well as from most parasite plants.

Good birdlime is of a greenish color, and sour flavor, somewhat resembling that of linseed oil; gluey, stringy, and tenacious. By drying in the air it becomes brittle, and may be powdered; but its viscosity may be restored by moistening it. It has an acid reaction with litmus paper. It contains resin, mucilage, a little free acid, coloring and extractive matter. The resin has been called VISCINE.

BISMUTH. (*Bismuth*, Fr.; *Wismuth*, Germ.) Called also marcasite and tin-glass. It was shown to be a metal somewhat different from lead, by G. Agricola, in 1546; Stahl and Dufay proved its peculiarity; but it was more minutely distinguished by Pott and Geoffroy, about the middle of the last century. It is a rare substance, occurring native, as an oxyde, under the name of bismuth ochre; as a sulphuret, called bismuth glance; as a sulphuret with copper, called copper bismuth ore; as also with copper and lead, called needle ore. It is found associated likewise with selenium and tellurium. The native metal occurs in various forms and colors, as white, reddish, and variegated; in primitive, and floetz formations, along with the ores of cobalt, nickel, copper, silver, and bismuth ochre; at the Saxon Erzegebirge, near Shneeberg, and Joh. Georgenstadt; also in Bohemia, Baden, Wurtemberg, Hessia, Sweden, Norway, England, and France.

The production of this metal is but a limited object of the smelting-works of the Saxon Erzgebirge at Schneeberg. It there occurs, mixed with cobalt speiss, in the proportion of about 7 per cent. upon the average, and is procured by means of a peculiar furnace of liquation, which is the most economical method, both as to saving fuel, and oxydizement of the bismuth.

The bismuth eliquation furnace at Schneeberg is represented in *figs.* 112, 113, and 114, of which the first is a view from above, the second a view in front, and the third a transverse section in the dotted line A B of *fig.* 112. *a* is the ash-pit; *b*, the fireplace; *c*, the eliquation pipes; *d*, the grate of masonry or brickwork, upon which the fuel is thrown through the fire-door *e e*. The anterior deeper lying orifice of the eliquation pipes is closed with the clay-plate *f;* which has beneath a small circular groove, through which the liquefied metal flows off. *g* is a wall extending from the hearth-sole nearly to the anterior orifice of the eliquation pipes, in which wall there are as many fire-holes, *h*, as there are pipes in the furnace: *i* are iron pans, which receive the fluid metal; *k*, a wooden water-

trough, in which the bismuth is granulated and cooled; *l*, the posterior and higher l... apertures of the eliquation pipes, shut merely with a sheet-iron cover. The granulation of bismuth drained from the posterior openings fall upon the flat surfaces *m*, and the

112

113

114
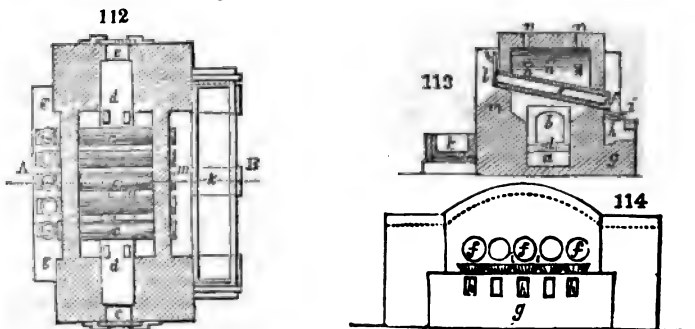
into the water-trough. *n n* are draught-holes in the vault between the two pipes, which serve for increasing or diminishing the heat at pleasure.

The ores to be cliquated (sweated) are sorted by hand from the gangue, broken into pieces about the size of a hazel nut, and introduced into the ignited pipes; one charge consisting of about ¼ cwt.; so that the pipes are filled to half their diameter, and three fourths of their length. The sheet-iron door is shut, and the fire strongly urged, whereby the bismuth begins to flow in ten minutes, and falls through the holes in the clay-plates into hot pans containing some coal-dust. Whenever it runs slowly, the ore is stirred round in the pipes, at intervals during half an hour, in which time the liquation is usually finished. The residuum, called bismuth barley (*graupen*), is scooped out with iron rakes into a water trough; the pipes are charged afresh; the pans, when full, have their contents cast into moulds, forming bars of from 25 to 50 pounds weight. About 20 cwt. of ore are smelted in 8 hours, with a consumption of 63 Leipzic cubic feet of wood. The total production of Shneeberg, in 1830, was 9800 lbs. The bismuth thus procured by liquation upon the great scale, contains no small admixture of arsenic, iron, and some other metals, from which it may be freed by solution in nitric acid, precipitation by water, and reduction of the subnitrated oxyde by black flux. By exposing the crude bismuth for some time to a dull red heat, under charcoal, arsenic is expelled.

Bismuth is white, and resembles antimony, but has a reddish tint; whereas the latter metal has a blueish cast. It is brilliant, crystallizes readily in small cubical facets, is very brittle, and may be easily reduced to powder. Its specific gravity is 9·83; and by hammering it with care, the density may be increased to 9·8827. It melts at 480° Fahr., and may be cooled 6 or 7 degrees below this point without fixing; but the moment it begins to solidify, the temperature rises to 480°, and continues stationary till the whole mass is congealed. When heated from 32° to 212°, it expands $\frac{1}{710}$ in length. When pure it affords a very valuable means of adjusting the scale of high-ranged thermometers. At strong heats bismuth volatilizes, may be distilled in close vessels, and is thus obtained in crystalline laminæ.

The alloy of bismuth and lead in equal parts has a density of 10·709, being greater than the mean of the constituents; it has a foliated texture, is brittle, and of the same color as bismuth. Bismuth, with tin, forms a compound more elastic and sonorous than the tin itself, and is therefore frequently added to it by the pewterers. With 1 of bismuth and 24 of tin, the alloy is somewhat malleable; with more bismuth, it is brittle. When much bismuth is present, it may be easily parted by strong muriatic acid, which dissolves the tin, and leaves the bismuth in a black powder. It has been said, that an alloy of tin, bismuth, nickel, and silver hinders iron from rusting. (*Erdmann's Journal.*) The alloy of bismuth with tin and lead was first examined by Sir I. Newton, and has been called ever since fusible metal. Eight parts of bismuth, 5 of lead, and 3 of tin, melt at the moderate temperature of 202° F.; but 2 of bismuth, 1 of lead, and 1 of tin, melt at 200·75° F. according to Rose. A small addition of mercury of course aids the fusibility. Such alloys serve to take casts of anatomical preparations. An alloy of 1 bismuth, 2 tin, and 1 lead, is employed as a soft solder by the pewterers; and the same has been proposed as a bath for tempering steel instruments. Cake-moulds, for the manufacturers of toilet soaps, are made of the same metal; as also excellent clichés for stereotype, of 3 lead, 2 tin, and 5 bismuth; an alloy which melts at 199° F. This compound should be allowed to cool upon a piece of pasteboard, till it becomes of a doughy consistence, before it is applied to the mould, to receive the impress of the stamp.

The employment of plates of fusible metal as safety *rondelles*, to apertures in the tops of steam boilers, has been proposed in France, because they would melt and give way at elevations of temperature under those which would endanger the bursting of the vessel; the fusibility of the alloy being proportioned to the quality of steam required for the engine. It has been found, however, that boilers, apparently secured in this way, burst, while the safety discs remained entire; the expansive force of the steam causing explosion so suddenly, that the fusible alloy had not time to melt or give way.

There are two, perhaps three, oxydes of bismuth; the first and the third, or the sub-oxyde and super-oxyde, are merely objects of chemical curiosity. The oxyde proper occurs native, and may be readily formed by exposing the metal to a red-white heat in a muffle, when it takes fire, burns with a faint blue flame, and sends off fumes which condense into a yellow pulverulent oxyde. But an easier process than that now mentioned is to dissolve the bismuth in nitric acid, precipitate with water, and expose the precipitate to a red heat. The oxyde thus obtained has a straw yellow color, and fuses at a high heat into an opaque glass of a dark-brown or black color; but which becomes less opaque and yellow after it has cooled. Its specific gravity is so high as 8·211. It consists of 89·87 of metal and 10·13 oxygen in 100 parts. The above precipitate, which is a sub-nitrate of bismuth, is called *pearl-white*, and is employed as a flux for certain enamels; as it augments their fusibility without imparting any color to them. Hence, it is used sometimes as a vehicle of the colors of other metallic oxydes. When well washed, it is employed in gilding porcelain; being added in the proportion of one fifteenth to the gold. But pearl-white is most used by ladies as a cosmetic for giving a brilliant tint to a faded complexion. It is called *blanc de fard*, by the French. If it contains, as bismuth often does, a little silver, it becomes gray or dingy colored on exposure to light. When the oxyde is prepared, by dropping the nitric solution into an alkaline ley in excess, if this precipitate is well washed and dried, it forms an excellent medicine; and is given, mixed with gum tragacanth, for the relief of cardialgia, or burning and spasmodic pains of the stomach.

Another sort of pearl-powder is prepared by adding a very dilute solution of common salt to the above nitric solution of bismuth, whereby a pulverulent sub-chloride of the metal is obtained in a light flocculent form. A similar powder of a mother-of-pearl aspect may be formed by dropping dilute muriatic acid into the solution of nitrate of bismuth. The arsenic always present in the bismuth of commerce is converted by nitric acid into arsenic acid, which, forming an insoluble arseniate of bismuth, separates from the solution, unless there be such an excess of nitric acid as to re-dissolve it. Hence the medicinal oxyde, prepared from a rightly-made nitrate, can contain no arsenic. If we write with a pen dipped in that solution, the dry invisible traces will become legible on plunging the paper in water.

It has been proposed to substitute bismuth for lead in assaying silver, as a smaller quantity of it answers the purpose, and, as its oxyde is more fluent, can therefore penetrate the cupel more readily, and give a more rapid result. But, independently of the objection from its high price, bismuth has the disadvantage of boiling up, as well as of *rocking* or vegetating, with the silver, when the cupellation requires a high heat. In extracting the silver from the galena found in the copper-mine of Yahlun, it has happened sometimes that the silver concreted towards the end of the operation, and produced a cauliflower excrescence, which had to be cupelled again with a fresh dose of lead. It was observed that, in this case, a portion of the silver had passed into the cupel. Berzelius detected in a sample of silver thus concreted the presence of bismuth.

The nitrate of bismuth, mixed with solution of tin and tartar, has been employed as a mordant for dyeing lilach and violet in calico printing.

BISTRE. (*Bistre*, Fr.; *bister*, Germ.) A brown color which is used in water colors, in the same way as China ink. It is prepared from wood-soot, that of beech being preferred. The most compact and best burned parcels of soot are collected from the chimney, pulverized, and passed through a silk sieve. This powder is infused in pure water, and stirred frequently with a glass ruler, then allowed to settle, when the water is decanted. If the salts are not all washed away, the process may be repeated with warm water. The paste is now to be poured into a long narrow vessel filled with water, stirred well, and left to settle for a few minutes, in order to let the grosser parts subside. The supernatant part is then to be poured off into a similar vessel. This process may be repeated twice or thrice, to obtain a very good bistre. At last the settled deposite is sufficiently fine, and when freed from its supernatant water, it is mixed with gum-water, moulded into proper cakes, and dried. It is not used in oil painting, but has the same effect in water-colors as brown pink has in oil.

BITUMEN, or ASPHALTUM. (*Bitume*, Fr.; *Erdpech*, Germ.) A black substance found in the earth, externally not dissimilar to pit-coal. It is composed of carbon, hydrogen, and oxygen, like organic bodies; but its origin is unknown. It

has not been observed among the primitive or older strata, but only in the secondary and alluvial formations. It constitutes sometimes considerable beds, as in the isle of Trinidad, where it occurs over an extensive district, in scattered masses. The greater part of the asphaltum to be met with in commerce comes from the Dead Sea, on whose shores it is cast up and gathered; whence it has got the name of Jewish bitumen. In its black color and fracture it resembles ordinary pitch. By friction it affords negative electricity. Its average density is 1·16. It melts at the temperature of boiling water, kindles very readily at the flame, burns brightly with a thick smoke, and leaves little ashes. Distilled by itself, it yields a peculiar bituminous oil, very little water, some combustible gases, and traces of ammonia. It leaves about one third of its weight of charcoal after combustion, and ashes, containing silica, alumina, oxyde of iron, sometimes a little lime, and oxyde of manganese. According to John, asphaltum may be decomposed, by different solvents, into three distinct substances. Water dissolves nothing; alcohol (anhydrous) dissolves out a yellow resin equal to 5 per cent. of the weight of the asphaltum; that resin is soluble in dilute alcohol and in ether. The portion not soluble in the alcohol gives up a brown resin to ether, amounting to 70 per cent. of the weight of the asphaltum. On evaporating off the ether, the resin remains of a brownish-black color, which dissolves readily in the volatile oils, and in the oil of petroleum. The portion of asphaltum which does not dissolve in ether is very soluble in oil of turpentine, and in oil of petroleum; but less so in oil of lavender. These three resinous principles dissolve all together by digestion in the oils of anise, rosemary, turpentine, olive, hemp-seed, nut, and linseed. Caustic potash dissolves a notable quantity of asphaltum; but carbonate of potash has no effect upon it.

Asphaltum enters into the composition of hydraulic cements, and into that of black varnishes, called japans, for coating iron trays, &c. A similar varnish may be prepared by dissolving 12 parts of fused amber, 2 parts of rosin, and 2 parts of asphaltum, in 6 parts of linseed oil varnish, to which 12 parts of oil of turpentine have been added.

There is a kind of bitumen found at Aniches, in France, in the department of the north, which is black, very fusible, and soft. It burns with flame. Alcohol, ether, and oil of turpentine extract from it a fatty substance, which may be saponified with alkalis.

The bitumen of Murindò, near Choco, in Columbia, is of a brownish-black color, soft, and has an earthy fracture. It has an acrid taste, burns with a smell of vanilla, and is said to contain a large quantity of benzoic acid. It appears to be the result of the decomposition of trees containing benzoin.

Asphaltum occurs abundantly at the surface of the salt lake Asphaltites, in Judea produced from springs in the neighborhood; it is floated down, gathers consistence and accumulates upon the surface of the lake; the winds drive it on the shores, and the inhabitants collect it for sale. Its inspissation diffuses a disagreeable smell in the air of that region, which is supposed by the natives to be powerful enough to kill birds where they attempt to fly across the lake.

But probably the most remarkable locality of asphaltum in the world is the entire basin, or rather plain of it, in the island of Trinidad, called the Tar Lake. It lies on the highest land in the island, and emits a strong smell, sensible at ten miles' distance. Its first appearance is that of a lake of water, but when viewed more nearly, it seems to be a surface of glass. In hot weather its surface liquefies to the depth of an inch, and it cannot then be walked upon. It is of a circular form, about three miles in circumference, and of a depth not ascertained. Large fissures frequently open and close up in it, whence the pitch has been supposed to float upon a body of water. The soil, for a considerable distance round it, consists of cinders and burnt earth, and presents in many points indications of convulsions by subterranean fire. In several parts of the neighboring woods, there are round holes and fissures in the ground, containing liquid bitumen to the depth of two inches.

Mr. Hatchett examined some specimens from Trinidad, and concluded that what had been heretofore supposed to be a pure mineral pitch was in reality only a porous stone of the argillaceous kind, much impregnated with bitumen.

These various bitumens belong exclusively to the secondary and tertiary geological formations, and are not found among primitive rocks, except very rarely in veins. They occur most generally in calcareous, argillaceous, and sandy strata, and also in volcanic districts. Petroleum frequently floats on the waters which issue from the volcanic mountains, or which lie at their base; even the sea is at times covered with it near the volcanic islands of Cape Verd. Mr. Breislack observed a petroleum spring rising from the bottom of the sea near the southern base of Vesuvius.

The substance with which bitumen seems to have the most constant and most remarkable relations, is sea-salt; so that almost all the countries most abundant in petroleum, as Italy, Transylvania, Persia, the environs of Babylon, the region of the Dead Sea, &c., contain salt mines, or lakes, or exhibit saline efflorescences. Iron pyrites is often impregnated with petroleum, or contains a bituminous nucleus.

The origin of bitumen is as little known as that of most of the productions of nature. Some regard it as an empyreumatic oil, a matter analogous to liquid resin or essential oil, resulting from the destruction of that astonishing, multitude of animals and vegetables buried in the earth, whose solid remains are daily brought to view in mineral researches. It has been also supposed that naphtha and petroleum are the product of coals decomposed either by the fire of volcanoes, by the subterranean combustion of coal itself, or by the decomposition of pyrites. The latter opinion is not supported by any direct evidence, but the two former are sufficiently probable.

Elastic Bitumen is a rare substance, found hitherto only near Castleton, in Derbyshire, in fissures of slaty clay.

Bituminous mastic, or cement, has been of late extensively employed in France for covering roofs and terraces, and lining water cisterns. The mineral bitumen used for the composition of this mastic is procured chiefly from the *Obsann* (Bas-Rhin), from the Parc (department de l'Ain), and from the *Puy-de-la-Poix* (department of Puy-de-Dome.) But boiled coal-tar answers equally well. In the neighborhood of these localities, there is a limestone impregnated with bitumen, which suits for giving consistence to the cement. This is well dried, ground to powder, sifted, and stirred while hot, in about one fifth its weight of melted asphaltum, contained in a cast-iron boiler. Dry chalk or bricks, ground and sifted, will suit equally well. As soon as this paste is made quite homogeneous, it is lifted out with an iron shovel or spoon, and spread in rectangular moulds, secured with pegs at the joints, fastened to a kind of platform of smoothed planks, covered with strong sheet-iron. The sides of these moulds should be previously smeared over with a thin coat of loam-paste, to prevent their adhesion to the mastic. Whenever the cake is cold, the frame is taken asunder, and it is removed from the iron plate by an oblong shovel, or strong spatula of iron. These cakes or bricks are usually 18 inches long, 12 broad, and 4 thick, and weigh about 70 lbs.

BITTER PRINCIPLE. (*Amère,* Fr.; *Bitterstoff,* Germ.) This principle has not been insulated hitherto by the chemist from the other proximate principles of plants, but its existence is sufficiently recognised by the taste. The following list contains the principal bitter substances, many of which have been used in the arts and in medicine.

Name.	Part employed.	Country.	Observations.
Quassia	Wood	Surinam, East Indies	Powerfully bitter
Wormwood	Herb	Great Britain	Ditto
Aloe	Inspissated juice	South Africa	Ditto
Angustura	Bark	South America	Ditto
Orange	Unripe fruit	South of Europe	Aromatic bitter
Ditto	Peel	Ditto	
Acorns	Root	Ditto	Ditto
Carduus Benedictus	Herb	Greek Archipelago	
Cascarilla	Bark	Jamaica	Ditto
Centaury	Herb	Great Britain	
Chamomile	Flowers		
Colocynth	Fruit	Levant	Intolerably bitter
Colombo	Root	East Africa	Very bitter
Fumitory	Herb	Great Britain	
Gentiana lutea	Root	Switzerland	Very bitter
Ground Ivy	Herb	Great Britain	
Walnut	Peels		With tannin
Island moss			With starch
Hops	Scales of the female flowers	Great Britain	Aromatic bitters
Milfoil	Herb flowers	Great Britain	
Large-leaved Satyrion	Herb	Great Britain	
Rhubarb	Root	China	Disagreeable odor
Rue	Herb	Great Britain	Bitter and sharp
Tansy	Herb flowers	Ditto	Bitter and offensive
Bitter trefoil	Herb	Ditto	
Simarouba	Bark	Guyana	
Bryony	Root	Great Britain	Sharp, bitter, nauseous
Coffee	Seeds	Arabia	

BLACK DYE. (*Teinte noire,* Fr.; *Schwartze farbe,* Germ.) For 1 cwt. of cloth, there are put into a boiler of middle size 18 lbs. of logwood, with as much Aleppo galls in

powder, and the whole, being enclosed in a bag, is boiled in a sufficient quantity of water for 12 hours. One third of this bath is transferred into another boiler with two pounds of verdigris; and the stuff is passed through this solution, stirring it continually during two hours, taking care to keep the bath very hot without boiling. The stuff is then lifted out, another third of the bath is added to the boiler, along with eight pounds of sulphate of iron or green vitriol. The fire is to be lowered while the sulphate dissolves, and the bath is allowed to cool for half an hour, after which the stuff is introduced, and well moved about for an hour, after which it is taken out to air. Lastly, the remaining third of the bath is added to the other two, taking care to squeeze the bag well. 18 or 22 lbs. of sumach are thrown in; the whole is just brought to a boil, and then refreshed with a little cold water; two pounds more of sulphate of iron are added, after which the stuff is turned through for an hour. It is thereafter washed, aired, and put again into the bath, stirring it continually for an hour. After this, it is carried to the river, washed well, and then filled. Whenever the water runs off clear, a bath is prepared with weld, which is made to boil for an instant; and after refreshing the bath the stuff is turned in to soften, and to render the black more fast. In this manner, a very beautiful black is obtained, without rendering the cloth too harsh.

Commonly more simple processes are employed. Thus the blue cloth is simply turned through a bath of gall-nuts, where it is boiled for two hours. It is next passed through a bath of logwood and sulphate of iron for two hours, without boiling, after which it is washed and fulled.

Hellot has found that the dyeing might be performed in the following manner :—For 20 yards of dark blue cloth, a bath is made of two pounds of fustic (morus tinctoria), 4¼ lbs. of logwood, and 11 lbs. sumach. After boiling the cloth in it for three hours it is lifted out, 11 lbs. of sulphate of iron are thrown into the boiler, and the cloth is then passed through it during two hours. It is now aired, and put again in the bath for an hour. It is, lastly, washed and scoured. The black is less velvety than that of the preceding process. Experience convinced him that the maddering prescribed in the ancient regulations only gives a reddish cast to the black, which is obtained finer and more velvety without madder.

A black may be dyed likewise without having given a blue ground. This method is employed for cloths of little value. In this case they are rooted; that is to say, they receive a dun ground with walnut husks, or the root of the walnut-tree, and are afterwards made black in the manner above described, or in some other way; for it is obvious that a black may be obtained by several processes.

According to Lewis, the proportions which the English dyers most generally adopt are, for one hundred and twelve pounds of woollen cloth previously dyed of a dark blue, about five pounds of sulphate of iron, as much gall nuts, and thirty pounds of logwood. They begin by galling the cloth, they then pass it through the decoction of logwood, to which the sulphate of iron has been added.

When the cloth is completely dyed, it is washed in the river, and passed through the fulling-mill till the water runs off clear and colorless. Some persons recommend, for fine cloths, to full them with soap water. This operation requires an expert workman, who can free the cloth thoroughly from the soap. Several recommend at its coming from the fulling to pass the cloth through a bath of weld, with the view of giving softness and solidity to the black. Lewis says, that passing the cloth through weld, after it has been treated with soap, is absolutely useless, although it may be beneficial when this operation has been neglected.

Different operations may be distinguished in dyeing *silk* black; the boiling of the silk, its galling, the preparation of the bath, the operation of dyeing, the softening of the black.

Silk naturally contains a substance called gum, which gives it the stiffness and elasticity peculiar to it in its native state; but this adds nothing to the strength of the silk, which is then styled raw; it rather renders it, indeed, more apt to wear out by the stiffness which it communicates; and although raw silk more readily takes a black color, yet the black is not so perfect in intensity, nor does it so well resist the re-agents capable of dissolving the coloring particles, as silk which is scoured or deprived of its gum.

To cleanse silk intended for black, it is usually boiled four or five hours with one fifth of its weight of white soap, after which it is carefully beetled and washed.

For the galling, nut-galls equal nearly to three fourths of the weight of the silk are boiled during three or four hours; but on account of the price of Aleppo galls, more or less of the white gall-nuts, or of even an inferior kind called galon, berry or apple galls, are used. The proportion commonly employed at Paris is two parts of Aleppo galls to from eight to ten parts of galon. After the boiling, the galls are allowed to settle for about two hours. The silk is then plunged into the bath, and left in it from twelve to thirty-six hours, after which it is taken out and washed in the river.

Silk is capable of combining with quantities, more or less considerable, of the astrin-

gent principle; whence results a considerable increase of weight, not only from the weight of the astringent principle, but also from that of the coloring particles, which subsequently fix themselves in proportion to the quantity of the astringent principle which had entered into combination. Consequently the processes are varied according to the degree of weight which it is wished to communicate to the silk; a circumstance requiring some illustration.

The commerce of silk goods is carried on in two ways; they are sold either by the weight, or by the surface, that is, by measure. Thus the trade of Tours was formerly distinguished from that of Lyons; the silks of the former being sold by weight, those of the latter, by measure. It was therefore their interest to surcharge the weight at Tours, and, on the contrary, to be sparing of the dyeing ingredients at Lyons; whence came the distinction of light black and heavy black. At present, both methods of dyeing are practised at Lyons, the two modes of sale having been adopted there.

Silk loses nearly a fourth of its weight by a thorough boiling, and it resumes, in the light black dye, one half of this loss; but in the heavy black dye, it takes sometimes upwards of a fifth more than its primitive weight; a surcharge injurious to the beauty of the black, and the durability of the stuff. The surcharged kind is denominated English black, because it is pretended that it was first practised in England. Since silk dyed with a great surcharge has not a beautiful black, it is usually destined for weft, and is blended with a warp dyed of a fine black.

The peculiarity of the process for obtaining the heavy black consists in leaving the silk longer in the gall liquor, in repeating the galling, in passing the silk a greater number of times through the dye, and even letting it lie in it for some time. The first galling is usually made with galls which have served for a preceding operation, and fresh gall-nuts are employed for the second. But these methods would not be sufficient for giving a great surcharge, such as is found in what is called the English black. To give it this weight, the silk is galled without being ungummed; and, on coming out of the galls, it is rendered supple by being worked on the jack and pin.

The silk-dyers keep a black vat, and its very complex composition varies in different dye-houses. These vats are commonly established for many years : and when their black dye is exhausted it is renovated by what is called in France a brevet. When the deposite which has accumulated in it is too great, it is taken out, so that at the end of a certain time nothing remains of the several ingredients which composed the primitive bath, but which are not employed in the brevet.

For the dyeing of raw silk black, it is galled in the cold, with the bath of galls which has already served for the black of boiled silk. For this purpose, silk, in its native yellow color, is made choice of. It should be remarked, that when it is desired to preserve a portion of the gum of the silk, which is afterwards made flexible, the galling is given with the hot bath of gall nuts in the ordinary manner. But here, where the whole gum of the silk, and its concomitant elasticity, are to be preserved, the galling is made in the cold. If the infusion of galls be weak, the silk is left in it for several days.

Silk thus prepared and washed takes very easily the black dye, and the rinsing in a little water, to which sulphate of iron may be added, is sufficient to give it. The dye is made in the cold; but, according to the greater or less strength of the rinsings, it requires more or less time. Occasionally three or four days are necessary; after which it is washed, it is beetled once or twice, and it is then dried without wringing, to avoid softening it.

Raw silk may be more quickly dyed, by shaking it round the rods in the cold bath after the galling, airing it, and repeating these manipulations several times, after which it is washed and dried as above.

Macquer describes a more simple process for the black by which velvet is dyed at Genoa; and he says that this process, rendered still simpler, has had complete success at Tours. The following is his description.

For 1 cwt. (50 kilogrammes) silk, 22 lbs. (11 kilogrammes) of Aleppo galls, in powder, are boiled for an hour in a sufficient quantity of water. The bath is allowed to settle till the galls have fallen to the bottom of the boiler, from which they are withdrawn; after which 32 lbs. of English vitriol (or copperas) are introduced, with 13 lbs. of iron filings, and 22 lbs. of country gum, put into a kind of two-handled cullender, pierced every where with holes. This kettle is suspended by two rods in the boiler, so as not to reach the bottom. The gum is left to dissolve for about an hour, stirring it from time to time. If, after this time, some gum remains in the kettle, it is a proof that the bath, which contains two hogsheads, has taken as much of it as is necessary. If, on the contrary, the whole gum is dissolved, from one to 4 lbs. more may be added. This cullender is left constantly suspended in the boiler, from which it is removed only when the dyeing is going on; and thereafter it is replaced. During all these operations the boiler must be kept hot, but without boiling. The galling of the silk is performed with one

third of Aleppo galls. The silk is left in it for six hours the first time, then for twelve hours. The rest, *secundum artem.*

Lewis states that he has repeated this process in the small way; and that by adding sulphate of iron progressively, and repeating the immersions of the silk a great number of times, he eventually obtained a fine black.

Astringents differ from one another as to the quantity of the principle which enters into combination with the oxyde of iron. Hence, the proportion of the sulphate, or of any other salt of iron, and that of the astringents, should vary according to the astringents made use of, and according to their respective quantities. Gall-nut is the substance which contains most astringent; sumach, which seems second to it in this respect, throws down (decomposes), however, only half as much sulphate of iron.

The most suitable proportion of sulphate of iron appears to be that which corresponds to the quantity of the astringent matter, so that the whole iron precipitable by the astringent may be thrown down, and the whole astringent may be taken up in combination with the iron. As it is not possible, however, to arrive at such precision, it is better that the sulphate of iron should predominate, because the astringent, when in excess, counteracts the precipitation of the black coloring particles, and has the property of even dissolving them.

This action of the astringent is such that, if a pattern of black cloth be boiled with gall-nuts, it is reducible to gray. An observation of Lewis may thence be explained. If cloth be turned several times through the coloring bath, after it has taken a good black color, instead of acquiring more body, it is weakened, and becomes brownish. Too considera— ble a quantity of the ingredients produces the same effect; to which the sulphuric acid, set at liberty by the precipitation of the oxyde of iron, contributes.

It is merely the highly oxydized sulphate which is decomposed by the astringent whence it appears, that the sulphate will produce a different effect according to its state of oxydizement, and call for other proportions. Some advise, therefore, to follow the method of Proust, employing it in the oxydized state; but in this case it is only partially decomposed, and another part is brought, by the action of the astringent, into the lower degree of oxydizement.

The particles precipitated by the mixture of an astringent and sulphate of iron have not at first a deep color; but they pass to a black by contact of air while they are moist.

Under *dyeing* I shall show that the black dye is only a very condensed color, and that it assumes more intensity from the mixture of different colors likewise deep. It is for this reason advantageous to unite several astringents, each combination of which produces a different shade. But blue appears the color most conducive to this effect, and it corrects the tendency to dun, which is remarked in the black produced on stuffs by the other astringents.

On this property is founded the practice of giving a blue ground to black cloths, which acquire more beauty and solidity the deeper the blue. Another advantage of this practice is to diminish the quantity of sulphuric acid which is necessarily disengaged by the precipitation of the black particles, and which would not only counteract their fixation, but would further weaken the stuff, and give it harshness.

For common stuffs, a portion of the effect of the blue ground is produced by the rooting.

The mixture of logwood with astringents contributes to the beauty of the black in a twofold way. It produces molecules of a hue different from what the astringents do, and particularly blue molecules, with the oxyde of copper, commonly employed in the black dyes; which appears to be more useful the more acetate the verdigris made use of contains.

The oil of weld, by which the dye of black cloth is frequently finished, may also contribute to its beauty, by the shade peculiar to its combination. It has, moreover, the advantage of giving softness to the stuffs.

The processes that are employed for wool, yield, according to the observation of Lewis, only a rusty black to silk; and cotton is hardly dyed by the processes proper for wool and silk. Let us endeavor to ascertain the conditions which these three varieties of dyeing demand.

Wool has a great tendency to combine with coloring substances; but its physical nature requires its combinations to be made in general at a high temperature. The combination of the black molecules may therefore be directly effected in a bath, in proportion as they form; and if the operation be prolonged by subdividing it, it is only with the view of changing the necessary oxydizement of the sulphate, and augmenting that of the coloring particles themselves.

Silk has little disposition to unite with the black particles. It seems to be merely by the agency of the tannin, with which it is previously impregnated, that these particles can fix themselves on it, especially after it has been scoured. For this reason, silk baths

should be old, and have the coloring particles accumulated in them, but so feebly suspended as to yield to a weak affinity. Their precipitation is counteracted by the addition of gum, or other mucilaginous substances. The obstacle which might arise from the sulphuric acid set at liberty is destroyed by iron filings, or other basis. Thus, baths of a very different composition, but with the essential condition of age, may be proper for this dye. For cotton black dye, see CALICO PRINTING.

BLACK PIGMENT. The finest light black is prepared principally for the manufacturing of printers' ink. In Messrs. Martin and Grafton's patent process, the black is obtained by burning common coal-tar, which should, however, be previously divested, as much as possible, of the ammoniacal liquor and acid mixed with it in the tank.

For this purpose, it is proposed that four casks should be employed, each capable of holding 130 gallons, and into every one of them are to be put about 60 gallons of the rough impure tar, to which an equal quantity of lime-water is to be added, and then agitated by machinery or manual labor until the lime-water is completely mixed with the tar. The vessels should next be suffered to rest for about six hours, by which time the tar will settle at the bottom of the casks, and the water may be drawn off. The casks containing the tar should now be filled with hot water, which may be supplied from the boiler of a steam engine, and the whole again agitated as before. This process may be repeated three times, suffering the tar to subside between each; and twelve hours should be allowed for settling from the last water, so that the whole of the tar and water may become separated, the water rising to the top of the cask, and the tar being left at the bottom in a pure state.

But, as some of the water will yet remain mechanically combined with the tar, it is proposed that the tar should be subjected to the process of distillation. For this purpose, a still, capable of holding 120 gallons, may be employed, in which about 50 gallons at one time may be operated upon; when, by a gentle heat, the water, and other impurities which the tar may have retained, will be driven off. As soon as the water appears to have evaporated, and the spirit runs fine and clear, the process of distillation should be stopped; and, when cold, the pure tar may be drawn off, and set apart for the purpose of being employed as contemplated in the patent.

The tar thus purified may be now converted into black, or it may be subjected to further rectification to divest it of the mineral pitch, or asphaltum, which is combined with the oil and spirit: the latter is to be preferred, because the mineral pitch, or asphaltum, is only inflammable at a high temperature, which renders it more troublesome to use in the process here contemplated, and also would cause the apparatus to require frequent cleaning from the carbonized pitch deposited. In order, therefore, to get rid of the mineral pitch, or asphaltum, forty gallons of the tar are to be introduced into a still, as before; and, instead of stopping the operation, as soon as the spirit begins to come over, the distillation is continued with a strong heat, so as to force over the whole of the oil and spirit, leaving the residuum of asphaltum in the still; this process, however, is known to every chemist, and need not be further explained.

In *fig.* 115, is exhibited a rude representation of the apparatus employed in preparing and collecting the fine light spirit black, produced by the combustion of the oil and
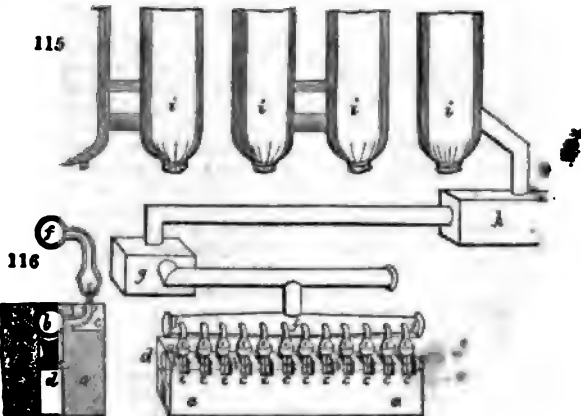
of coal-tar, after it has been purified as above described. *a* is the brickwork which supports a number of burners issuing from a tube, *b*, within, and here shown by

dots, as passing along its whole length. *Fig.* 116 is a section of the brickwork, with the tube, burner, and receiver, as will be described hereafter. The tube may be called the tar main, as it is intended to be filled with tar: it is constructed of cast iron, and from it issue several (in this figure twenty-four) jets or burners, *c, c, c;* any other number may be employed. *d* is a furnace under the tar main, the flue of which extends along, for the purpose of heating the tar to the boiling point, in order to facilitate the process. From the main, *b,* the tar flows into the jets *c;* wicks are introduced into the jets, and, when set fire to, by a red-hot stick, will burn and emit a very considerable quantity of smoke; which it is the object of this apparatus to conduct through many passages, for the purpose of collecting its sooty particles.

There are a number of hoods, *e, e, e,* or bonnets, as they are termed, all of which, through their pipes, have communication with, or lead into a main chimney, *f, f.* Into these hoods or bonnets the smoke of the burners ascends, and from thence passes into the main chimney *f,* and thence through the smoke tubes into the box *g:* here the heaviest particles of the black deposite themselves; but, as the smoke passes on through the farther pipes, a deposite of the second, or finer, particles of black takes place in the box *h.* From hence other smoke proceeds through other pipes into a series of canvass bags, *i, i, i,* which are proposed to be about eighteen feet long, and three in diameter. These bags are connected together at top and bottom alternately, and through the whole series the smoke passes up one bag and down the next, depositing fine black, called spirit black, upon the sides of the canvass. After the jets have continued burning for several days, the bags are to be beaten with a stick, so that the black may fall to the bottom; and, when a sufficient quantity has accumulated, the bags may be emptied and swept out. Thus seventy or eighty bags may be employed; so that the smoke should pass through a length of about 400 yards, the farthest of which will be found to contain the finest black. The last bag should be left open, in order to allow the vapor to escape into the open air.

The main tar tube will require to be emptied every four or five days, in order to clear it from the pitchy matter that may have subsided from the burners, and they also will require to be frequently poked with a wire, to clear off the black which forms upon the edges, and to drive down the carbonized tar which attaches itself to the upper part of the jets.

BLEACHING (*Blanchiment,* Fr.; *Bleichen,* Germ.) is the process by which the textile filaments, cotton, flax, hemp, wool, silk, and the cloths made of them, as well as various vegetable and animal substances, are deprived of their natural color, and rendered nearly or altogether white. The term bleaching comes from the French verb *blanchir,* to whiten. The word *blanch,* which has the same origin, is applied to the whitening of living plants by making them grow in the dark, as when the stems of celery are covered over with mould.

The operations which the bleacher has recourse to differ according to the nature of the bleaching means, the property of the stuff to be bleached, and local customs or circumstances; and the result is also obtained with more or less rapidity, certainty, economy, and perfection. The destruction of the coloring matters attached to the bodies to be bleached is effected either by the action of the air and light, of chlorine, or sulphurous acid; which may be considered the three bleaching powers employed for manufacturing purposes.

Bleaching by the influence of air and sunshine is the most ancient, and still the most common, method in several civilized countries; it is also supposed by many to be the least injurious to the texture of yarn and cloth. The operations it involves are very simple, consisting in the exposure of the goods upon a grass-plat to the sky, with their occasional aspersion with moisture if necessary, in addition to the rain and dew. The atmospheric air effects the bleaching by means of its oxygenous constituent, which combines with the coloring matter, or its elements carbon and hydrogen, and either makes it nearly white, or converts it into a substance easily soluble in water and alkaline solutions. This natural process is too slow to suit the modern demands of the cotton and linen manufacturers. Fortunately for them, a new bleaching agent, unknown to our forefathers, has been discovered in chlorine, formerly called oxymuriatic acid, an agent modified by chemistry so as to give an astonishing degree of rapidity, economy, and perfection, to this important art. It is, however, not a little surprising, that the science which has so greatly advanced its practical part should have left its theory far from complete, and should afford no satisfactory answers to the two following questions.—What is the action of the solar rays upon the coloring matter? How do air and chlorine operate upon this principle? Some suppose that light *predisposes* the coloring matter to combine with oxygen; others fancy that it acts merely in the manner of a high temperature, so as to determine a reaction between the elements of that substance, and to cause a new combination possessed of peculiar properties. It is generally admitted at the present day, that a portion of the oxygen of the air passes into the coloring matter, and changes its con-

stitution. This is, however, probably not the part which oxygen plays, nor is it the only principle in the atmosphere which exercises a bleaching influence. Neither is the action of chlorine such as has been commonly represented in our chemical systems.

But if authors offer us only vague hypotheses concerning the three principal agents, light, oxygen, chlorine, they afford no information whatever concerning the phenomena due to greasy spots so frequently found upon cotton cloth, and so very troublesome to the bleacher. It has indeed been sometimes said in bleach-works, that fatty substances are no longer soluble in alkalis, when they are combined with oxygen. The very reverse of this statement is probably nearer the truth.

The object of bleaching is to separate from the textile fibre, by suitable operations, all the substances which mask its intrinsic whiteness : or which, in the course of ulterior dyeing operations, may produce injurious effects. In this latter respect, cotton deserves especial consideration. This substance is covered with a resinous matter, which obstructs its absorption of moisture, and with a yellow coloring matter in very small quantity, often so inconsiderable in some cottons, that it would be unnecessary to bleach them, before submitting them to the dyer, were it not that the manipulations which they undergo introduce certain impurities which are more or less injurious, and must be removed. It is in fact a circumstance well known in the factories, that unbleached cottons may be dyed any dark color, provided they are deprived of that matter which makes them difficult to moisten. The substances present in cotton goods are the following :—

1. The resinous matter natural to the cotton filaments.
2. The proper coloring matter of this vegetable.
3. The paste of the weaver.
4. A fat matter.
5. A cupreous soap.
6. A calcareous soap.
7. The filth of the hands.
8. Iron, and some earthy substances.

1. The matter which prevents the moistening of cotton wool may be separated by means of alcohol, which, when evaporated, leaves thin yellowish scales, soluble in alkalis, in acids, and even in a large quantity of boiling water. For a long time the bleaching process commenced with the removal of this resinous stuff, by passing the cloth or the yarn through an alkaline ley. This was called scouring ; it is now nearly laid aside.

2. The coloring matter of cotton seems to be superficial, and to have no influence on the strength of the fibres; for the yarn is found to be as strong after it has been stripped by caustic soda of its resinous and coloring matters, as it was before. The coloring matter is slightly soluble in water, and perfectly in alkaline leys. When gray calico is boiled in lime-water, it comes out with a tint darker than it had before ; whence it might be supposed that the coloring matter was not dissolved out, even in part. This, however, is not the case ; for if we filter the liquor, and neutralize it with an acid, we shall perceive light flocks, formed of the resinous substance, united with the coloring matter. The dark color of the cloth is to be ascribed solely to the property which lime possesses of browning certain vegetable colors. This action is here exercised upon the remaining color of the cloth.

It may be laid down as a principle, that the coloring matter is not directly soluble by the alkalis ; but that it becomes so only after having been for some time exposed to the joint action of air and light, or after having been in contact with chlorine. What change does it thereby experience, which gives it this solubility ? Experiments made upon pieces of cloth placed in humid oxygen, in dry oxygen, in moist chlorine, and in dry chlorine, tend to show that hydrogen is abstracted by the atmosphere; for in these experiments proofs of dis-hydrogenation appeared, and of the production of carbonic acid. In all cases of bleaching by chlorine, this principle combines immediately with the hydrogen of the coloring matter, and forms muriatic acid, while the carbon is eliminated. Undoubtedly water has an influence upon this phenomenon, since the bleaching process is quicker with the humid chlorine than with the dry; but this liquid seems to act here only mechanically, in condensing the particles of the gas into a solution. We should also take into account the great affinity of muriatic acid for water.

3. The weaver's dressing is composed of farinaceous matters, which are usually allowed to sour before they are employed. It may contain glue, starch, gluten; which last is very soluble in lime-water.

4. When the dressing gets dry, the hand-weaver occasionally renders his warp-threads more pliant by rubbing some cheap kind of grease upon them. Hence it happens, that the cloth which has not been completely freed from this fatty matter will not readily imbibe water in the different bleaching operations ; and hence, in the subsequent dyeing a dunging, these greasy spots, under peculiar circumstances, somewhat like lithographic drawings, strongly attract the aluminous and iron mordants, as well as the dye-stuffs, and

occasion stains which it is almost impossible to discharge. The acids act differently upon the fatty matters, and thence remarkable anomalies in bleaching take place. When oil is treated with the acetic or muriatic acid, or with aqueous chlorine, it evolves no gas, as it does with the sulphuric and nitric acids, but it combines with these substances so as to form a compound which cannot be dissolved by a strong boiling ley of caustic soda. Carbonic acid acts in the same way with oil. On the other hand, when the oils and fats are sufficiently exposed to the air, they seize a portion of its oxygen, and become thereby capable of saponification, that is, very soluble in the alkalis.

5. When the hand-weaver's grease continues in contact for a night with the copper dents of his reed, a kind of cupreous soap is formed, which is sometimes very difficult to remove from the web. Lime-water does not dissolve it; but dilute sulphuric acid carries off the metallic oxyde, and liberates the margaric acid, in a state ready to be acted on by alkalis.

6. When cloth is boiled with milk of lime, the grease which is uncombined unites with that alkaline earth; and forms a calcareous soap, pretty soluble in a great excess of lime-water, and still more so in caustic soda. But all fats and oils, as well as the soaps of copper and lime, cease to be soluble in alkaline leys, when they have remained a considerable time upon the goods, and have been in contact with acetic, carbonic, muriatic acids, or chlorine. These results have been verified by experiment.

7. Cotton goods are sometimes much soiled, from being sewed or tamboured with dirty hands; but they may be easily cleansed from this filth by hot water.

8. Any ferruginous or earthy matters which get attached to the goods in the course of bleaching, are readily removable.

We are now prepared to understand the true principles of bleaching cotton goods, for the most delicate operations of the calico printer.

1. The first process is steeping, or rather boiling, the goods in water, in order to remove all the substances soluble in that liquid.

2. The next step is to wash or scour the goods by the dash-wheel or the stocks. This is of great importance in the course of bleaching, and must be repeated several times; so much so, that in winter, when the water of the dash-wheel is cold, the bleaching is more tedious and difficult. Yarn and very open fabrics do not much need the dash-wheel.

By these first two operations, the woven goods lose about sixteen per cent. of their weight, while they lose only two parts out of five hundred in all the rest of the bleaching.

3. In the third place the calicoes are boiled with milk of lime, whereby they are stripped of their gluten, and acquire a portion of calcareous soap. Formerly, and still in many bleach-works, the gluten was got rid of by a species of fermentation of the farinaceous dressing; but this method is liable to several objections in reference to the calico printer. 1. The fermentative action extends sometimes to the goods and weakens their texture, especially when they are piled up in a great heap without being previously washed. 2. The spots of grease, or of the insoluble soaps, become thereby capable of resisting the caustic alkalis, and are rendered in some measure indelible; an effect due to the acetic and carbonic acids generated during fermentation, and which will be easily understood from what has been said concerning the action of acids on fatty substances. It is not, therefore, without good reason that many practical men throw some spent leys into the fermenting vats, to neutralize the acids which are formed. Were it not for the presence of fat, fermentation, skilfully conducted, would be an excellent means of carrying off the gluten; and the steep is therefore applicable to power-loom goods, which are not polluted with grease.

4. The goods are now subjected to a caustic soda ley, which dissolves out the soaps of lime and copper, as well as that portion of the coloring matter which is sufficiently dis-hydrogenated to be capable of combining with it. This bucking with ley, which is repeated several times upon the goods, in order to purge them completely from the fatty matter present in the hand-loom webs, and also partially introduced in the spinning, is almost the only operation to which yarns for Turkey red are subjected. After being boiled in a caustic soda ley, they are passed through solutions of chloride of lime, and afterwards through the acid steep.

5. When the goods are sufficiently bucked in the leys, they are either exposed to chlorine, or laid out on the grass; sometimes both are had recourse to for delicate work. These different modes of action have the same influence on the coloring matter, but they give rise to different effects in reference to greasy stains.

The goods are dipped in a solution of chloride of lime, which should be kept tepid by means of steam. Alongside of the chlorine cistern, there is another filled with dilute sulphuric or muriatic acid. When the goods are taken out of the chlorine, they are drained on the top of its cistern till no more liquid runs off them, and they are then plunged into the *sour*. The action of the acid in the present case may be easily ex-

plained. In proportion as a salt of lime is formed, this base quits the chlorine, and allows it to act freely upon the coloring matter. Thus we prevent the development of too great a quantity of chlorine at once, which would be apt to injure the fibres; and we pursue both a prudent and economical plan. Only so much chlorine as is strictly necessary is called forth, and hence it excites no smell in the apartment.

The chlorine serves to acidify the coloring matter, by abstracting a portion of its hydrogen; but we must take the greatest care that there is no grease upon the goods before immersion in it, for the consequence would be, as above shown, very troublesome spots. When the cloth is laid out upon the grass, it is the oxygen of the air which acidifies the coloring matter; for which reason, the dew, which contains much air rich in oxygen, singularly accelerates the bleaching process. It is likewise, by absorbing oxygen from the atmosphere, that fats or oils pass to the state of margaric and oleic acids, and become most easily saponified. Should the goods, however, be left too long on the grass, the fats absorb carbonic acid, and become insoluble in leys.

6. The goods must now receive a new soda ley, to dissolve out that portion of the coloring matter which has been dis-hydrogenated in the chlorine of the air, as well as the grease, if any perchance remained in the soluble state. These last two operations are to be several times repeated, because the coloring matter should be removed only by degrees, for fear of injuring the texture of the goods, by subjecting them to too much chlorine at a time.

7. We finish with the dilute sulphuric acid, which should be very weak and tepid. It dissolves out the iron, and some earthy matters occasionally found upon cotton. The goods must be most carefully washed at the dash-wheel, or in a stream of water on quitting the sour ba h, for if the acid were allowed to dry in them, it would infallibly injure their texture by its concentration. In winter, if the goods are allowed to get frozen with the acid upon them, they may likewise be damaged.

We may here observe, that when the goods are not to remain white, their bleaching may be completed with a ley; for though it leaves a faint yellow tint, this is no inconvenience to the dyer. But when they are to be finished with a starching after the last ley, they must have another dip of the chlorine to render the white more perfect. An immersion in the dilute acid has nearly the same effect.

The principles expounded above lead to this important consequence, that when we wish to bleach goods that are free from greasy stains, as is the case generally with the better kinds of muslins, or when we wish to bleach even greasy goods for the starch finish, we may content ourselves with the following operations:—

1. Boiling in water.
2. Scouring by the stocks or the dash-wheel.
3. Bucking with milk of lime.
4. Passing through chlorine, or exposure on the grass.
5. Bucking, or bouking with milk of lime. These two latter operations require to be alternated several times, till the whole of the coloring matter be removed.
6. Souring.

The bleaching of goods, which are never laid down on the green, and which are not dried between two operations, may be completed in a couple of days. They answer as well for the printer as the others, and they are as white. Cotton fibres or yarns suffer no diminution of their strength, when the cloth has been properly treated in the above described processes.

Accurate experiments have demonstrated that their strength is not impaired by being boiled in milk of lime for two hours at the ordinary pressure, provided they be constantly kept covered with liquid during the whole ebullition, and that they be well washed immediately afterwards; or, by being boiled in pure water under the pressure of ten atmospheres of steam; or by being boiled under the same pressure in a caustic soda ley, marking 3° of Tweedale, or specific gravity 1·015, though it has increased to double the density in the course of the boil, by the escape of the steam; or by being boiled under the atmospheric pressure at 14° of Tweedale, or specific gravity of 1·070; or by being immersed for eight hours in chloride of lime, capable of decoloring three times its bulk, of test solution of indigo (See CHLORINE); and by being afterwards dipped in sulphuric acid of specific gravity 1·067, Tweedale 14°; or by being steeped for eighteen hours in sulphuric or muriatic acid of specific gravity 1·035, 7° Tweedale.

In other well-conducted bleach-works the following is the train of operations:—
1. Cleansing out the weaver's dressing by steeping the cloth for twelve hours in cold water, and then washing it at the stocks or the dash-wheel. 2. Boiling in milk of lime, of a strength suited to the quality of the goods, but for a shorter time than with the soda ley; two short operations with the lime, with intermediate washing, being preferable to one of greater duration. 3 and 4. Two consecutive leys of ten or twelve hours' boiling, with about two pounds of soda chrystals for 1 cwt. of cloth. 5. Exposure to the air for six or eight days, or the application of the chloride of lime and the sulphuric

acid. 6. A ley of caustic soda, like the former, sometimes with less alkali. 7. Exposure to the air for six or eight days, or chlorine and the sour, as above. 8. Caustic soda ley, as before. 9. Chlorine and the sour. 10. Rinsing in hot water, or scouring at the dash-wheel.

If the number of vessels to be heated exceeds four or five, there is an economy in using steam as the medium of heat; but under this number there is an advantage in the direct application of fire to a boiling or bucking apparatus; since when only two vessels are in activity, there is a waste of fuel by the extra steam power. It deserves to be remarked, also, that the increase of the bulk of the liquid by the condensation of the steam, does not permit the spent white ley to be turned to use for the green goods, on account of its excessive dilution. With the milk of lime boil, however, this dilution would be rather an advantage.

It has been found that the introduction of bran into the fermenting steep (when this is used) endangers the texture of the goods, by causing a putrefactive fermentation in some places.

When in the milk of lime boil there is too much of this caustic earth, or when it is poured in on the top of the goods, they are apt to suffer damage. The milk of lime should be introduced from beneath into the under compartment of the bucking apparatus. For the same reason, after the caustic soda ley, the vessel should be filled up with water, if the goods be not immediately transferred to the dash-wheel. When they are allowed to become partially dry on the top, they are easily injured. The copper of the bucking apparatus ought to be of a size proportioned to that of the surmounting crib or vat; for when it is too small, the liquid is too long of being brought into proper circulation, and the goods may be meanwhile injured. In a bucking apparatus, which requires five or six hours to be brought into full play, those goods are very apt to be injured, which lie immediately under the overflow pipe.

When the chloride of lime steep is too strong, sometimes small round holes are made in the calico, just as if they had been cut out by a punch, especially in the borders or thicker parts of the goods. This accident is owing to the presence of bubbles of chlorine. From the saturated state of the liquid, they remain gaseous a sufficient length of time for corroding the parts of the cloth with which they are in contact. These will be obviously the denser parts, for they confine the gas most completely, or prevent its diffusion through the mass. This evil is prevented by diluting the chloride steep to the proper degree, and moving the goods through it.

The greasy spots, described above, show themselves in the maddering by attracting the dye-stuff more copiously than the pure parts of the cloth, so as to mottle it; they are also recognised in the white goods by being somewhat repulsive of moisture. When the combination of fatty matters with chlorine takes place at the surface of cotton goods, it is of a nature to resist the action of alkalis. It is the stearine, or the principle of suet, particularly, which, by this means, acquires such a strong affinity for cottons; the elaine, or the principle of oils, has no such remarkable affinity. Lime, in some circumstances, seems to act as a mordant to greasy matters, and to fix them fast. Hence the weaver should be prohibited, in all cases, from allowing candle-grease to touch his web. Goods soiled with it should never be allowed to lie by in the ware-house, but be immediately cleansed before the air has fixed the stearine by converting it into margaric acid. Lime should, in these cases, be prudently employed; chlorine should never be used till the greasy stains are thoroughly removed; and the bleacher should never warrant his pieces for the printer till he has verified some of them by the water test.

I shall conclude this general analysis of the principles of bleaching by a few precepts. Avoid lime, at the first ley, for goods which contain greasy spots; but use it freely after one or two soda leys, and apply two soda leys after it. Do not apply chlorine between these leys, but reserve it for the final operation. By this plan the goods will be well bleached and very little worn. Use the souring steeps freely, giving them after each ley, whether of lime or soda, since the calcareous base, with which the greasy spots get charged merely from hard water, is an obstacle to the further action of the leys.

I shall now give some practical instructions concerning the several steps of the bleaching process, as applied to cotton, linen, silk, and wool.

The first thing which the cotton bleacher does, is to mark the pieces with the initials of the owner, by means of a stamp imbued with coal tar. The linen bleacher marks with nitrate of silver, a far more expensive substance, but one which resists better the severer treatment which his goods are destined to undergo. •

The cotton goods are generally singed before they are sent to the bleacher, and this is done either by passing them rapidly over a red-hot semi-cylinder of iron, or over a row of gas flames, by Mr. Hall's ingenious contrivance. (See SINGEING.) Each piece is next creased together lengthwise like a rope, folded into a bundle, and fixed by a noose at the end. In this open state it is easily penetrated by the water of the soaking cistern into which it is thrown. It is then scoured by the dash or wash-wheel. It is now ready for

he bucking or steaming apparatus, where it is treated with milk of lime. The steam chamber resembles the bucking vessel, without its bottom copper; that is to say, a few inches below the grated bottom of the bucking tub, there is a close iron sole, through the centre of which the steam is admitted by several small apertures, for the purpose of diffusing it throughout the goods, and causing a liquid circulation by its pressure, as the steam does in the proper bucking boiler. One pound of lime previously made into cream consistenced mixture, and passed through a sieve, is used for every thirty or forty pounds of cloth, according to its color and texture; and this cream mixed with more water is interstratified with the pieces, as they are laid regularly in the vessel. Whenever this is stocked with goods, all their interstices are filled up with water. After the lime bucking, the cloth is transferred to the dash-wheel.

A pound of cloth requires for its whitening about half a pound of good average chloride of lime or bleaching powder, as it is commonly called, and this ought to be dissolved in about three gallons of water. Mr. Crum of Thorniebank, near Glasgow, an extensive and excellent bleacher, has so modified Dr. Dalton's ingenious plan of testing the power of bleaching liquors by green sulphate of iron, as to give it much greater precision for the bleacher's use, than the discoloration of indigo originally proposed by Berthollet. Mr. Crum dissolves four ounces of fresh green vitriol in hot water, and then adds the solution of bleaching powder by small quantities at a time, till the iron becomes wholly peroxydized, when the smell of chlorine will become perceptible. When the bleacher has once found by trial the proper blanching power which his chlorine steep ought to have, he can verify its standard, by seeing how much of it must be added to an ounce, or any given weight of fresh copperas, dissolved in hot water, to cause the peroxydizement and the exhalation of the peculiar odor. M. Gay Lussac's new method by arsenious acid will be described under chlorine. From the experiments which I made some years ago,[*] upon indigo, it will be seen that this dye stuff is so variable in its quantity of coloring matter, that no two chemists operating with it independently, as a test for chloride of lime, could arrive at the same result. They must provide themselves with absolute indigo, by an expensive and troublesome process, not suited to the busy bleacher. The vitriolage, as the French term it, or the souring of the English bleacher, consists in immersing the goods for four hours in dilute sulphuric acid, containing one gallon of oil of vitriol to from 25 to 30 of water, thoroughly intermixed by stirring; for the density of the acid is an obstacle to its equal distribution through the water. This dilute acid will have a density of from 1·047 to 1·040, and will contain from 7 to 6½ per cent. by weight of the oil of vitriol.

The goods are now washed, and then boiled for eight or nine hours in an alkaline ley, containing about two pounds of crystals of soda, or their equivalent in soda ash or pearl-ash, for every 100 lbs. of cloth. The ley must be made previously caustic by quick lime. A washing in the wheel follows this boil; and then a chlorine steep for five hours in a liquor two thirds of the strength of the former. It is next soured in the dilute sulphuric acid, for two, three, or four hours, according to the color and quality of the cotton, and then thoroughly washed.

The cloth is now bleached white, but cannot be presented in the market till it undergoes certain finishing processes. The piece is elongated from the folds which it contracts during the rotation of the dash-wheel by being thrown into a stream of water in a cistern, terminated by the squeezing rollers, which take in the end of the piece, and run it through between them, with the effect of making it nearly dry. Two pieces of cloth pass simultaneously through the rollers, and are disentangled spontaneously, so to speak, without the help of hands.

The squeezing rollers or squeezers, for discharging the greater part of the water from the yarns and goods in the process of bleaching, are represented in *figs.* 117, 118, the

117   118
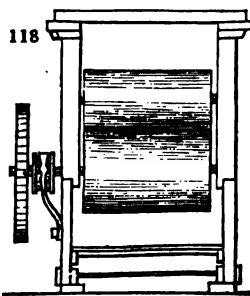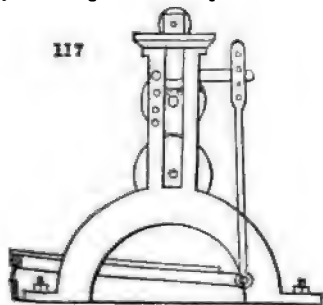
former being a side-view, to show how the roller gudgeons lie in the slots of the frame, and how the shaft of the upper roller is pressed downward by a weighted lever, through a vertical junction rod, jointed at the bottom to a nearly horizontal bar, on whose end the proper weight is hung. In *fig.* 118, these rollers of birch-wood are shown in face; the under one receiving motion through the toothed wheel on its shaft, from any suitable power of water or steam. Upon the shaft of the latter, between the toothed wheel and the roller, the lever and pulley for putting the machine into and out of gear are visible. The under roller makes about 25 revolutions in the minute, in which time three pieces of goods, stitched endwise, measuring 28 yards each, may be run through the machine, from a water trough on one side, to a wooden grating upon the other.

When the goods are run through, they are carried off upon a grated wheelbarrow, in a nearly dry state, and transferred to the spreading machine, called at Manchester a *candroy.* In many bleach-works, however, the creased pieces are pulled straight by the hands of women, and are then strongly beat against a wooden stock to smooth out the edges. This being done, a number of pieces are stitched endwise together, preparatory to being mangled.

Calender.—*Fig.* 120 is a cross section of this machine, and *figs.* 119, 121, are front views broken off. The goods are first rolled upon the wooden cylinder *a*, near the

119   120   121
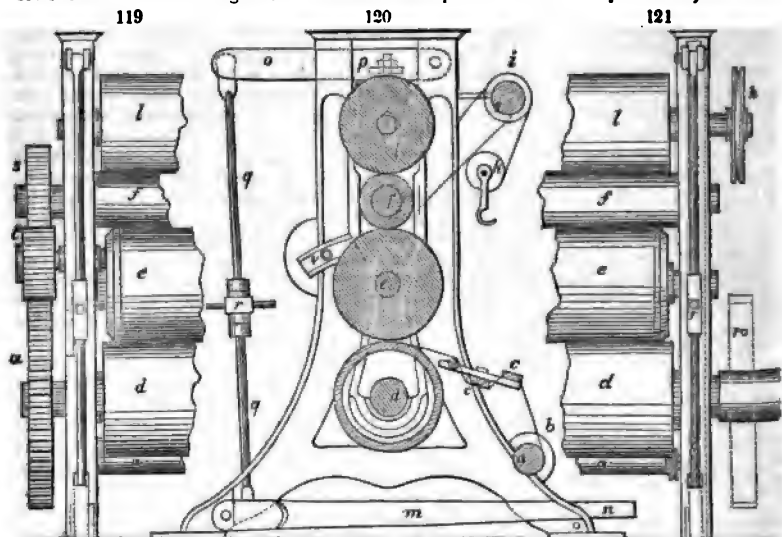
ground; by the tension roller *b*, upon the same cylinder, the goods receive a proper degree of stretching in the winding off. They then pass over the spreading bars *c c c*, by which they are still more distended; next round the hollow iron cylinder *d*, 16 inches diameter, and the paper cylinder *e*, of like dimensions; thence they proceed under the second massive iron cylinder *f*, of 8 inches diameter, to be finally wound about the projecting wooden roller *g*. This is set in motion by the pulleys *h, fig.* 121, and *i, fig.* 120, and receives its proper tension from the hanging roller *k*; *l* is a press cylinder, of 14 inches diameter, made of plane-tree wood. By its means we can at all times secure an equal degree of pressure, which would be hardly possible did the weighted lever press immediately upon two points of the calender rollers. The compression exercised by the cylinders may be increased at pleasure by the bent lever *m*, weights being applied to it at *n*. The upper branch of the lever *o* is made fast by screws and bolts at *p*, to the upper press-cylinder. The junction leg *q* is attached to the intermediate piece *r*, by left and right-handed screws, so that according as that piece is turned round to the right or the left, the pressure of the weighted roller will be either increased or diminished. By turning it still more, the piece will get detached, the whole pressure will be removed, and the press-roller may be taken off; which is a main object of this mechanism.

The unequable movement of the cylinders is produced by the wheels *s t u*, of which the undermost has 69, the uppermost has 20, and the carrier-wheel *t*, either 33, 32, or 20 teeth, according to the difference of speed required. The carrier-wheel is bolted on at *v*, and adjusted in its proper place by means of a slot. To the undermost iron cylinder, the first motion is communicated by any power, for which purpose either a rigger (driving pulley) is applied to its shaft at *u*, or a crank motion. If it be desired to

operate with a heated calender, the undermost hollow cylinder may be filled with hot steam, admitted through a stuffing-box at one end, and discharged through a stuffing-box at the other, or by a red-hot iron roller.

Pure starch would be too expensive a dressing for common calico shirtings, and therefore an extemporaneous starch is made by mixing one pound of flour with one gallon of water, and allowing the mixture to ferment in a warm place for twenty-four hours. In this way, a portion of *lactic* acid is formed, which dissolves the gluten, or separates it from the starch; so that when the whole is thrown upon a sieve, a liquid paste passes through, which, being boiled, answers well for stiffening the goods, without giving them a gray tinge. The paste is thinned with water to the desired degree, and faintly tinged with solution of indigo. The starch, which is sometimes thickened with porcelain clay, Paris plaster, or Spanish white, is put into a trough, and is evenly imparted to the cloth as this is drawn down through it, by the traction of rollers. There is a roller near the bottom of the trough, round which the cloth is made to run, to secure its full impregnation; while the upper rollers serve to expel its excess of the starch, and throw it back into the cistern. See STARCHING APPARATUS.

The goods are next dried in an apartment heated by two, three, or more flues, running along the floor, and covered usually with fire-tiles. At first the heat is moderate, but it is gradually raised to upwards of 110° F.

The goods must now be passed again through the calender, in order to receive their final smoothness and lustre. They are, in the first place, damped with a peculiar machine, furnished with a circular brush, whose points revolve in contact with water in a trough placed beneath them, and sprinkle drops of water upon the goods as they are drawn forward by a pair of cylinders. They are then subjected to the powerful pressure of the calender rollers.

The calendered pieces are neatly folded into compact parcels, and stamped with the marks of each particular manufacturer, or various devices to suit the markets for which they are designed. They are finally piled on the sole of an hydraulic press, with a sheet of pasteboard between each piece; but with occasional plates of iron to secure uniformity of pressure throughout. When sufficiently condensed by the press, they are taken out, and despatched to their respective manufacturers in a state ready for sale.

There are no less than 25 steps in the bleaching of calicoes, many of them effected with expensive machinery; yet the whole do not produce to the bleacher more than 10 pence per piece of 24 yards.

The following system was pursued, a few years back, by a skilful bleacher of muslins near Glasgow :—

" In fermenting muslin goods, we surround them with our spent leys, from the temperature of 100° to 150° F., according to the weather, and allow them to ferment for 36 hours. In boiling 112 lbs. = 112 pieces of yard-wide muslin, we use 6 or 7 lbs. of pearl-ashes, and 2 lbs. of soft soap, with 360 gallons of water, and allow them to boil for 6 hours; then wash them, and boil them again with 5 lbs. of pearl-ashes and 2 lbs. of soft soap, and allow them to boil 3 hours; then wash them with water, and immerse them into the solution of oxymuriate of lime, at 5 on the test-tube, and allow them to remain from 6 to 12 hours; next wash them, and immerse them into dilute sulphuric acid at the specific gravity of 3½ on Tweedale's hydrometer = 1·0175, and allow them to remain an hour. They are now well washed, and boiled with 2¼ lbs. of pearl-ashes, and 2 lbs. of soft soap for half an hour; afterwards washed and immersed into the oxymuriate of lime as before, at the strength of 3 on the test-tube, which is stronger than the former, and allowed to remain for 6 hours. They are again washed, and immersed in diluted sulphuric acid at the specific gravity of 3 on Tweedale's hydrometer = 1·015. If the goods be strong, they will require another boil, steep, and sour. At any rate, the sulphuric acid must be well washed out before they receive the finishing operation with starch.

" With regard to the lime, which some use instead of alkali immediately after fermenting, the same weight of it is employed as of pearl-ashes. The goods are allowed to boil in it for 15 minutes, but no longer, otherwise the lime will injure the fabric."

More recently the plan adopted is as follows; by which the purest whites are produced for the London market.

" Lime is seldom used for our finer muslin goods, as it is found to injure their fabric, and the colors do not keep for any length of time.

" An alkaline ley is made by boiling equal weights of lime and soda together for an hour: this alkali is used for boiling goods the same as potash, but without soap.

" In finishing jaconets or muslins, after washing them from the sour, they are run through spring-water containing a little fine smalts, which give them a clear shade; if of a coarse fabric, a little well-boiled starch is added to the water. From this they are wrung or pressed, and taken up by the selvage for the breadthing frame, and are run off it upon a tin cylinder heated by steam, by which the piece is completely dried

in 15 minutes: it is then stripped from the cylinder, neatly folded and pressed, which finishes the piece for the market. From 6*d*. to 9*d*. per piece of 12 yards is obtained for the bleaching and finishing of those goods.

" Book muslins, after being washed from the sour, are wrung or pressed; then they are hung up to dry in a heated stove, previous to being put into starch, prepared by boiling 3 lbs. of it to every 5 gallons of water, with 20 ounces of smalts: they are wrung out of this starch, and taken to a room heated to 110° F.; the starch is wrought into the piece till clear, then taken into a cold room, and the selvages dressed or set, before being put on the breadthing frame in the heated stove, where the piece is stretched to its length, while three or four persons at each selvage keep the piece to its breadth. If a stiff finish is wanted, they keep exactly opposite each other; but in breadthing the piece of elastic, they cross the piece in breadthing, which gives it a springy elastic finish. From 9*d*. to 15*d*. per piece of 12 yards is obtained for the bleaching and finishing of these goods.

" Sewed trimmings, flounces, and dresses are run through spring water containing fine smalts with a little well-boiled starch. They are then taken to the drying-stove, where they are stented till dry, which finishes the piece for the market. From 6*d*. to 8*d*. per piece is obtained for trimmings and flounces, and from 9*d*. to 1*s*. for dresses, bleaching and finishing."

In the bleaching of cotton cloth, where fixed colors are previously dyed in the yarn before it is woven into cloth, such as the Turkey or Adrianople red, and its compounds of lilach or purple, by the addition of iron bases, various shades of blue from indigo, together with buff and gold color, tinged with the oxydes of iron, great care is necessary.

The common process of bleaching pulicates, into which permanent colors are woven is, to wash the dressing or starch well out in cold water; to boil them gently in soap, and, after again washing, to immerse them in a moderately strong solution of the oxy muriate of potash; and this process is followed until the white is good: they are then soured in dilute sulphuric acid. If the goods are attended to in a proper manner, the colors, in place of being impaired, will be found greatly improved, and to have acquired a delicacy of tint which no other process can impart to them.

Pulicates, or ginghams, which have been woven along with yarn which has been previously bleached, are first freed by washing from the starch or dressing: they are then washed, or slightly boiled with soap. After which, they are completely rinsed in pure spring water, and then soured.

Besides these common processes for bleaching, another was some time ago introduced, which consisted in immersing the cotton or linen goods in pretty strong solution of caustic alkali, and afterwards exposing them to the action of steam in a close vessel. It is now generally abandoned.

The cotton or linen goods, having been previously cleaned by steeping and washing, were, after being well drained, steeped in a solution of caustic alkali of the specific gravity of 1020. After the superfluous alkaline ley had been drained from them, they were arranged on a grating in a receiver. The cover was then placed on the vessel, and firmly screwed down; and the steam was admitted by turning the stopcock of the pipe which communicated with a steam boiler of the common construction.

The stains which come out upon maddered goods, in consequence of defective bleaching, are called in this country *spangs*. Their origin is such as I have described above, as the following statement of facts will show. The weaver of calicoes receives frequently a fine warp so tender from bad spinning or bad staple in the cotton, that it will not bear the ordinary strain of the heddles, or friction of the shuttle and reed, and he is obliged to throw in as much weft as will compensate for the weakness or thinness of the warp, and make a good marketable cloth. He of course tries to gain his end at the least expense of time and labor. Hence, when his paste dressing becomes dry and stiff, he has recourse to such greasy lubricants as he can most cheaply procure; which are commonly either tallow or butter in a rancid state, but the former, being the lowest priced, is preferred. Accordingly, the weaver, having heated a lump of iron, applies it to a piece of tallow held over the warp in the loom, and causes the melted fat to drop in patches upon the yarns, which he afterwards spreads more evenly by his brush. It is obvious, however, that the grease must be very irregularly applied in this way, and be particularly thick on certain spots. This irregularity seldom fails to appear when the goods are bleached or dyed by the common routine of work. Printed calicoes examined by a skilful eye will be often seen to be stained with large blotches evidently occasioned by this vile practice of the weaver. The ordinary workmen call these *copper* stains, believing them to be communicated in the dyeing copper. Such stains on the cloth are extremely injurious in dyeing with the indigo vat. The following plan is adopted by some Scotch bleachers, with the effect, it is said, of effectually counteracting spangs from grease.

The goods having been singed and steeped in pure water, as is customary in common bleaching, they are passed through a pair of rollers to press out the impurities which have been loosened by the steeping. It must here, however, be observed, that where the

expense of one extra drying can be afforded, the process might be very much improved by steeping the brown calicoes for thirty or forty hours before singeing, because this would separate much of that impurity which usually becomes fixed in the stuff on its being passed over the hot cylinders. When the pieces have been thus singed, steeped, and pressed, they are boiled four times, ten or twelve hours at each time, in a solution of caustic potash, of the specific gravity of from 1·0127 to 1·0156, washing them carefully and thoroughly in pure water between each of these boilings. They are then immersed in a solution of the chloride of potash, originally of the strength of 1·0625, and afterwards reduced with twenty-four times its measure with water.

When the preparation is good, these proportions will whiten cotton goods completely in eight hours. In this steep they are, however, generally suffered to remain twelve hours. It has been supposed that the common bleaching liquor (chloride of lime) cannot, without injury, be substituted for chloride of potash, but I believe this to be a mistake. Some printers take the pieces from this solution, and, while wet, lay them upon the grass, and there expose them to the sun and weather for two or three days. They are thence removed to the sours, made of the specific gravity of about 1·0254 at the temperature of 110° of Fahrenheit. In bleaching common goods, and such as are not designed for the best printing, the specific gravity of the sours is varied from that of 1·0146 to that of 1·0238, if weighed when they become of the temperature of the atmosphere. In these they are suffered to lie for five or six hours, after which they are taken to the dash-wheel and washed thoroughly. When this operation is finished, they are submitted to four more boilings as before, with a solution of caustic potash; taking care to wash well between each of these boilings. Sometimes pearl-ash, made caustic, is used for the last of these boilings, lest the sulphur, which always exists in the potashes of commerce, should impair the whites. They are next immersed in the diluted chloride of potash, of the strength before mentioned; after which they are well washed in pure water, and then winched for half an hour in common sours. The last process is that of careful washing in plenty of clean water, after which they are not put into the stove, but are immediately hung up in the airing sheds to dry gradually. The water must be good, and abundant.

The number of operations, as here described, is great; but I know of no other mode of procedure by which perfect bleaching is so likely to be effected at all times and in all seasons, without disappointment. It must here be remarked, that, for the best purposes of printing, it would not be sufficient to take goods which have been bleached in the common way and finish these by the better process; because the sulphate of lime deposited in the cloth by that operation will be apt to spoil them for madder colors; at least, a printer who is curious in his business would hesitate to work up such cloth.

Bucking or Bowking.—This is one of the most important operations in the bleaching of both cotton and linen goods. There are several methods whereby this process is carried on; but of these we shall select only two, distinguishing them as the old and new method of bucking. In the former way, the cloths have been steeped in the alkaline ley, as before described, and afterwards well washed, are regularly arranged in a large wooden vat, or kieve; a boiler of sufficient capacity is then filled with caustic alkaline ley, which is heated to the temperature of blood. The boiler is then emptied by a stop-cock upon the linens in the kieve, until they are covered with the liquor. After having remained on the cloth for some time, it is run off by a stop-cock, at the bottom of the kieve, into an iron boiler sunk in the ground, from whence it is raised into the boiler by a pump. The heat is now elevated to a higher temperature, and the ley again run upon the goods in the kieve; from whence it is returned into the boiler, as before described: and these operations are continued, always increasing the heat, until the alkaline ley is completely saturated with the coloring matter taken from the cloth, which is known by its having acquired a completely offensive smell, and losing its causticity.

When we consider the effect which heated liquids have upon colored vegetable matter, we shall see the propriety of the temperature of the alkaline ley being gradually increased. Thus, when vegetable substances are hastily plunged into boiling liquids, the coloring matter, in place of being extracted, is, by this higher temperature, fixed into them. It is on this principle that a cook acts in the culinary art, when the green color of vegetables is intended to be preserved: in place of putting them into water when cold, they are kept back until the water is boiling; because it is well known that, in the former case, the green color would be entirely extracted, whereas, when the vegetables are not infused until the water is boiling, the color is completely preserved or fixed. On the same principle, when the temperature of the alkaline ley is gradually raised, the extractive and coloring matter is more effectually taken from the cloth; and the case is reversed when the ley is applied at the boiling temperature: so much so, that linen which has been so unfortunate as to meet with this treatment, can never be brought to a good white.

When the alkaline ley is saturated with coloring matter, it is run off as unfit for

further use in this operation; but, were the goods to be instantly taken o
kieve, and carried to be washed in the dash-wheel while hot, a certain porti
coloring matter would be again fixed into them, which is extremely d
eradicate. In order to prevent this, the most approved bleachers run warm w
the cloth as soon as the impure ley is run off: this combines with and carri
of the remaining impurities. A stream of water is then allowed to run upon
in the kieve, until it comes off almost transparent. The goods are now to
to the wash stocks, or to the dash-wheel, to be further cleaned, with the
efficacy.

The improved mode of bowking was the invention of Mr. John Laurie, a
Glasgow. It is now practised by many bleachers in Lancashire, some on mo
plans than others; but we shall give the description of the kind of apparatus
of by those whose experience and skill have rendered them the most
judges.

In *fig.* 122, A B C D is the wooden kieve, or kier, containing the cloth;
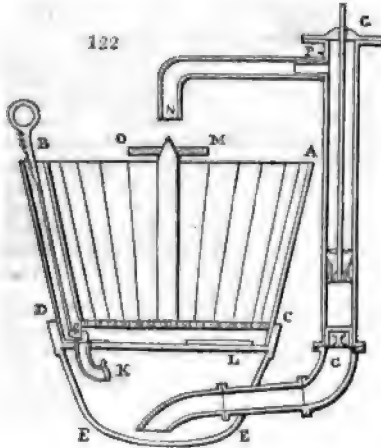
represents the cast-iron boiler;
pump; g K, the pipe of comm
between the kieve and the boil
pipe has a valve on each of its ex
that on the upper extremity, w
prevents the ley from running
boiler, and is regulated by the
by means of the rod and har
The valve at K admits the ley;
ing inwards, it prevents the st
escaping through the pipe g
boiler has a steam-tight iron c
and at C D, in the kieve, is
grating, a small distance above
of the boiler.

At M O is a broad plate of
order to spread the ley over
It is hardly necessary to say
boiler has a furnace, as usual, f
purposes.

While the ley is at a low ten
the pump is worked by the mill
engine. When it is sufficiently heated, the elasticity of the steam forces it u
the valves of the pump, in which case it is disjoined from the moving power.

N P is a copper spout, which is removed at the time of taking the cloth c
kieve.

The boilers A, *fig.* 123, used in bleaching, are of the common form, havi
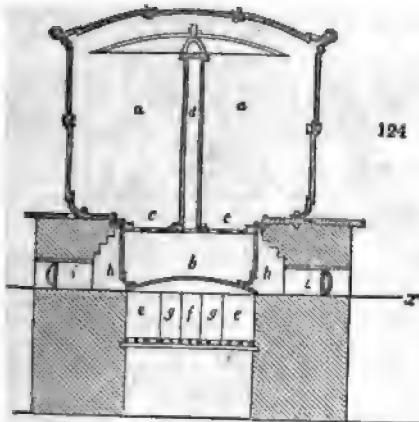

cock, H G, at bottom, for running off the
They are commonly made of cast-iron, an
pable of containing from 300 to 600 gallons
according to the extent of the business
order that the capacity of the boilers may be
they are formed so as to admit of a crib
strongly hooped, or, what is preferable, of
to be fixed to the upper rim or edge of it.
the goods from the bottom, where the heat
forcibly, a strong iron ring, covered wit
made of stout rope, c, is allowed to rest si
inches above the bottom of the boile
double ropes are attached to the ring E,
drawing the goods when sufficiently boil
have each an eye for admitting hooks
running tackle of a crane. Where mo
than one are employed, the crane is
that, in the range of its sweep, it may withdraw the goods from any of them.
purpose, the crane turns on pivots at top and bottom; and the goods are raise
ered at pleasure, with double pulleys and sheaves, by means of a cylinder mov
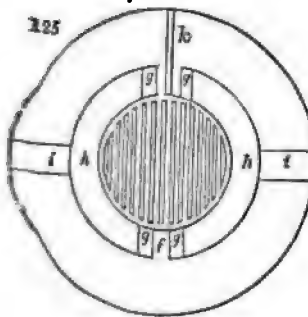iron wheels. The lid is secured by the screw bolts D D, and rings B B. F
valve.
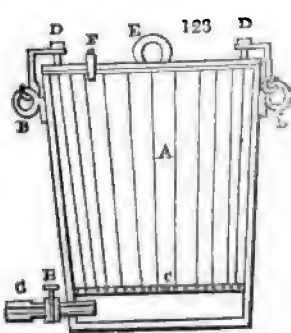
The efficacy of Laurie's bowking apparatus is remarkable. While th
——dually rising, a current of fresh ley is constantly presented to the differen
           iting the goods, so as to increase its detersive powers. Besides, the

which the apparatus is worked, first by the water-wheel or steam-engine, and then by its intrinsic operation, puts it completely out of the power of servants to slight the work; not to speak of the great saving of alkali, which, in many cases, has been found to amount to 25 per cent.

A simple modification of the bowking apparatus is shown in *figs.* 124, 125, 126; the first being a vertical section, the second, a horizontal section in the line *x* of the first. It consists of two parts: the upper wide part, *a a*, serves for the reception of the goods, and the lower or pot, *b*, for holding the ley; *c c* is an iron grating, shown apart in *fig.* 126. The grating has numerous square apertures in the middle of the disc, to which the rising pipe *d* is screwed fast. The upper cylinder is formed of cast iron, or of sheet iron well riveted at the edges; or sometimes of wood, this being secured at its under edge into a groove in the top edge of the ley-pot. The mouth of the cylinder is constructed usually of sheet iron. *c e* is the fire-grate, whose upper surface is shown in *fig.* 125; it is made of cast iron, in three pieces. The flame is parted at *f*, and passes through the two apertures *g g*, into the flues *h h*, so as to play round the pot, as is visible in *fig.* 125; and escapes by two outlets into the chimney. The apertures *i i* serve for occasionally cleaning out the flues *h h*, and are, at other times, shut with an iron plate. In the partition *f*, which separates the two openings *g g*, and the flues *h h*, running round the pot, there is a circular space at the point marked with *k*, *fig.* 125, in which the large pipe for discharging the waste ley is lodged. The upper large cylinder should be incased in wood, with an intermediate space filled with saw-dust, to confine the heat. The action of this apparatus is exactly the same as of that already explained.
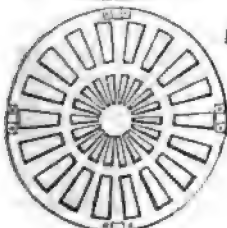
Besides the boiling, bucking, and other apparatus above described, the machinery and utensils used in bleaching are various, according to the business done by the bleacher. When linen or heavy cotton cloths are whitened, and the business is carried on to a considerable extent, the machines are both complicated and expensive. They consist chiefly of a water-wheel, sufficiently powerful for giving motion to the wash-stocks, dash-wheels, squeezers, &c., with any other operations where power is required.

Figs. 127, 128, represent a pair of wash-stocks. A A are called the stocks, or feet. They are suspended on iron pivots at B, and receive their motion from wipers on the revolving shaft c. The cloth is laid in at D, and by the alternate strokes of the feet, and the curved form of the turnhead E, the cloth is washed and gradually turned. At the same time, an abundant stream of water rushes on the cloth throughout holes in the upper part of the turnhead. Wash-stocks are much used in Scotland and in Ireland. In the latter country they are often made with double feet, suspended above and below two turnheads, and wrought with cranks instead of wipers. Wash-stocks, properly constructed, make from 24 to 30 strokes per minute.
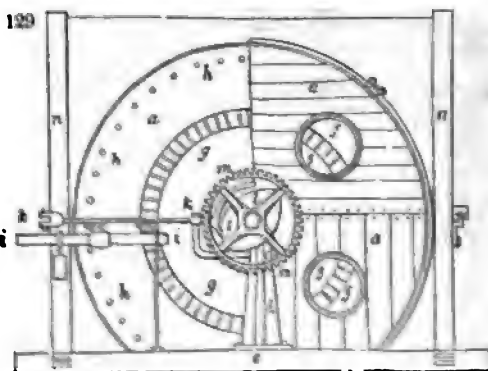
This mode of washing is now entirely given up in Lancashire, where a preference is given to what are called dash-wheels and squeezers. The dash are small water-wheels, the inside of which is divided into four compartments, and closed up, leaving only a hole in each compartment for putting in the cloth.

There are, besides, smaller openings for the free admission and egress of the water employed in cleansing. The cloth, by the motion of the wheel, is raised up in one part of
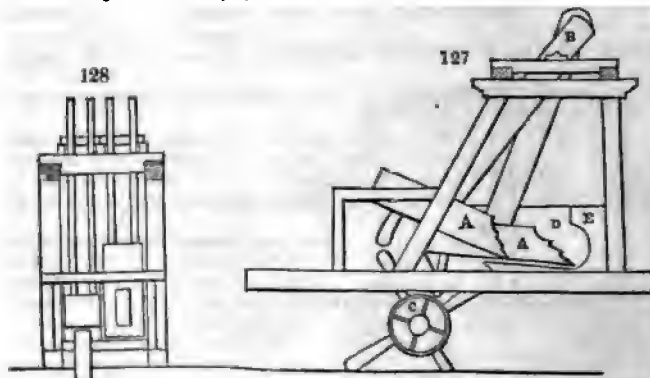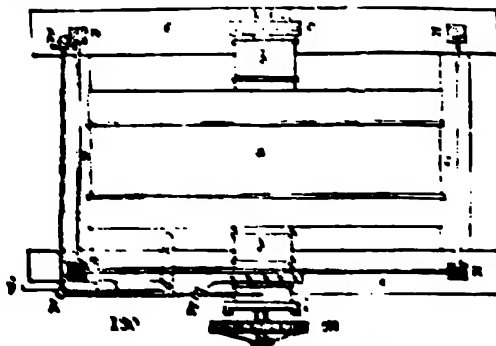

the revolution of the wheel; while, by its own weight, it falls in another. This kind of motion is very effectual in washing the cloth, while, at the same time, it does not injure its strength. The plan, however, where economy of water is of any importance, is very objectionable; because the wheel must move at by far too great a velocity to act to advantage as a water-wheel.

The wash or dash-wheel, now driven by power in all good bleach and print-works, is represented in *fig.* 129, upon the left side in a back view, and upon the right side in a front view (the sketch being halved). *Fig.* 130 is a ground plan.

a a is the washing-wheel; *b b* its shaft-ends; *c c* their brass bearings or plummer-blocks, supported upon the iron pillars *d d*. The frame is made of strong beams of wood, *e e*. bound together by cross bars with mortises. *f f*, two of the circular apertures, each leading to a quadrantal compartment within the dash-wheel. In the back view (the left-hand half of the figure the brass grating *g g*, of a curvilinear form, is seen, through which the jets of water are admitted into the cavity of the wheel: *h h*, are the round orifices, through which the foul water runs off, as each quadrant passes the lower part of its revolution; *i*, a water-pipe, with a stop-cock for regulating the washing-jets. *k k*, the lever for throwing the driving-crab *l*, or coupling-box, into or out of gear with the shaft of the wheel. This machine is so constructed, that the water-cock is opened or shut by the same leverage which throws the wheel into or out of gear. *m*, a wheel, fixed upon the round extremity of the shaft of the dash-wheel, which works into the toothed pinion connected

he prime mover. When the end of the lever *k*, whose fork embraces the coupling-
pon the square part of the shaft, is pushed forwards or backwards, it shifts the clutch
r out of gear with the toothed wheel *m*. In the latter case, this wheel turns with
tion without affecting the dash-wheel. *n n*, holdfasts fixed upon the wooden frame,
ich the boards *o o* are attached, for preventing the water from being thrown about
: centrifugal force.

: dash-wheel is generally from 6 to 7 feet in diameter, about 30 inches wide, and re-
. the power of about two horses to drive it.

m one to two pieces of calico may be done at once in each quadrantal compartment,
: course of 8 or 10 minutes; hence, in a day of 13 hours, with two such wheels
pieces of yard-wide goods may be washed.

er the process of washing by the dash-wheel, the water is expressed from the cloth
ans of the squeezers already described.

ching of Linen.—Linen contains much more coloring matter than cotton. The
: loses nearly a third of its weight, while the latter loses not more than a twentieth.
bres of flax possess, in the natural condition, a light gray, yellow, or blond color.
: operation of rotting, or, as it is commonly called, water-retting, which is employed
ble the textile filaments to be separated from the boon, or woody matter, the color
es darker, and, in consequence probably of the putrefaction of the green matter of
rk, the coloring substance appears. Hence, flax prepared without rotting is much
and its coloring matter may be in a great measure removed by washing with
leaving the filaments nearly white. Mr. James Lee obtained a patent in 1812, as
t discovered that the process of steeping and dew-retting is unnecessary, and that
nd hemp will not only dress, but will produce an equal if not greater quantity of
lurable fibre, when cleaned in the dry way. Mr. Lee stated that, when hemp or
lants are ripe, the farmer has nothing more to do than to pull, spread, and dry
in the sun, and then to break them by proper machinery. This promising im-
ment has apparently come to naught, having been many years abandoned by the
ee himself, though he was favored with a special act of parliament, which permit-
e specification of his patent to remain sealed up for seven years, contrary to the
ll practice in such cases.

: substance which gives steeped flax its peculiar tint is insoluble in boiling water,
ls, and in alkalis; but it possesses the property of dissolving in caustic or carbonated
ne leys, when it has possessed the means of dehydrogenation by previous exposure
gen. Hemp is, in this respect, analogous to flax. The bleaching of both depends
this action of oxygen, and upon the removal of the acidified dye, by means of an

This process is effected generally by the influence of air in combination with
nd moisture acting on the linen cloth laid upon the grass : but chlorine will effect
me object more expeditiously. In no case, however, is it possible to acidify the
:ompletely at once, but there must be many alternate exposures to oxygen or chlo-
nd alkali, before the flax becomes white. It is this circumstance alone which ren-
ne bleaching of linen an apparently complicated business.

ing made these preliminary observations with regard to the method of applying the
e leys used in bleaching linen cloth, I shall now bring the whole into one point of
ny detailing the connexion of these processes, as carried on at a bleach-field, which
iformly been successful in returning the cloth of a good white, and has otherwise
satisfaction to its employers; and I shall only remark, that I by no means hold it
he best process which may be employed, as every experienced bleacher knows that
ies must be varied, not only according to existing circumstances, but also according
nature of the linens operated upon.

rder to avoid repetition, where washing is mentioned, it must always be under-
hat the linen is taken to the wash-stocks or dash-wheel, and washed well in them
ne hours. This part of the work can never be overdone; and on its being properly
ed between every part of the bucking, boiling, steeping in the chloride of lime
a, and souring, not a little of the success of bleaching depends. By exposure is
that the linen cloth is taken and spread upon the bleach-green for four, six, or
ays, according as the routine of business calls for the return of the cloth, in order
ergo further operations.

rcel of goods consists of 360 pieces of those linens which are called Britannias.
piece is 35 yards long; and they weigh, on an average, 10 lbs. each : the weight of
reel is, in consequence, about 3600 lbs. avoirdupois weight. The linens are first
d, and then steeped in waste alkaline ley, as formerly described under these pro-
; they then undergo the following operations:—

1st,	Bucked with 60 lbs.	pearl-ashes,	washed,	exposed	on the field.	
2d,	Ditto	80	ditto	ditto	ditto	ditto.
3d,	Ditto	90	potashes	ditto	ditto	ditto.
4th,	Ditto	80	ditto	ditto	ditto	ditto.

5th, Bucked with 80 lbs. pearl-ashes, washed, exposed on the field.
6th, Ditto   50   ditto   ditto   ditto   ditto.
7th, Ditto   70   ditto   ditto   ditto   ditto.
8th, Ditto   70   ditto   ditto   ditto   ditto.
9th, Soured one night in dilute sulphuric acid, washed.
10th, Bucked with 50 lbs. pearl-ashes, washed, exposed on the field.
11th, Immersed in the chloride of potash or lime 12 hours.
12th, Boiled with 30 lbs. pearl-ashes, washed, exposed on the field.
13th, Ditto   30   ditto   ditto   ditto   ditto.
14th, Soured, washed.

The linens are then taken to the rubbing-board, and well rubbed with a strong lather of black soap, after which they are well washed in pure spring water. At this period they are carefully examined, and those which are fully bleached are laid aside to be blued, and made up for the market; while those which are not fully white are returned to be boiled, and steeped in the chloride of lime or potash; then soured, until they are fully white.

By the above process, 690 lbs. weight of alkali is taken to bleach 360 pieces of linen, each piece consisting of 35 yards in length; so that the expenditure of alkali would be somewhat less than 2 lbs. for each piece, were it not that some parts of the linens are not fully whitened, as above noted. Two pounds of alkali may therefore be stated as the average quantity employed for bleaching each piece of goods.

The method of bleaching linens in Ireland is similar to the foregoing; any alteration in the process depending upon the judgment of the bleacher in increasing or diminishing the quantity of alkali used. But it is common, at most bleach-fields, to steep the linens in the chloride of lime or potash at an early stage of the process, or after the goods have undergone the fifth or sixth operation of bucking. By this means those parts of the flax which are most difficult to bleach are more easily acted upon by the alkali; and, as before noticed, souring early in very dilute sulphuric acid, assists greatly in forwarding the whitening of the linens. Mr. Grimshaw, calico-printer, near Belfast, was the first who recommended early souring, which has since been very generally adopted.

The bleaching of Silk.—Silk in its raw state, as spun by the worm, is either white or yellow of various shades, and is covered with a varnish, which gives it stiffness and a degree of elasticity. For the greater number of purposes to which silk is applied, it must be deprived of this native covering, which was long considered to be a sort of gum. The operation by which this coloring matter is removed is called scouring, cleansing, or boiling. A great many different processes have been proposed for freeing the silk fibres from all foreign impurities, and for giving it the utmost whiteness, lustre, and pliancy; but none of the new plans has superseded, with any advantage, the one practised of old, which consists essentially in steeping the silk in a warm solution of soap; circumstance placed beyond all doubt by the interesting experiments of M. Roard. The alkalis, or alkaline salts, act in a marked manner upon the varnish of silk, and effect its complete solution; the prolonged agency of boiling water, alone answers the same purpose; but nothing agrees so well with the nature of silk, and preserves its brilliancy and suppleness so perfectly, as a rapid boil with soap-water. It would appear, however, that the Chinese do not employ this method, but something that is preferable. Probably the superior beauty of their white silk may be owing to the superiority of the raw material.

The most ancient method of scouring silk consists of three operations. For the first, or the *ungumming*, thirty per cent. of soap is first of all dissolved in clean river water by a boiling heat; then the temperature is lowered by the addition of a little cold water, by withdrawing the fire, or at least by damping it. The hanks of silk, suspended upon horizontal poles over the boiler, are now plunged into the soapy solution, kept at a heat somewhat under ebullition, which is an essential point; for if hotter, the soap would attack the substance of the silk, and not only dissolve a portion of it, but deprive the whole of its lustre. The portions of the hanks plunged in the bath get scoured by degrees; the varnish and the coloring matter come away, and the silk assumes its proper whiteness and pliancy. Whenever this point is attained, the hanks are turned round upon the poles, so that the portion formerly in the air may be also subjected to the bath. As soon as the whole is completely ungummed, they are taken out, wrung by the peg, and shaken out; after which, the next step, called the *boil*, is commenced. Into bags of coarse canvass, called *pockets*, about 25 lbs. or 35 lbs. of ungummed silk are enclosed, and put into a similar bath with the preceding, but with a smaller proportion of soap, which may therefore be raised to the boiling point without any danger of destroying the silk. The ebullition is to be kept up for an hour and a half, during which time the bags must be frequently stirred, lest those near the bottom should suffer an undue degree of heat. The silk experiences in these two operations a loss of about 25 per cent. of its weight.

The third and last scouring operation is intended to give the silk a slight tinge, which

renders the white more agreeable, and better adapted to its various uses in trade. In this way we distinguish the China white, which has a faint cast of red, the silver white, the azure white, and the thread white. To produce these different shades, we begin by preparing a soap-water so strong as to lather by agitation; we then add to it, for the China white, a little annotto, mixing it carefully in; and then passing the silk properly through it, till it has acquired the wished for tint. As to the other shades, we need only azure them more or less with a fine indigo, which has been previously washed several times in hot water, and reduced to powder in a mortar. It is then diffused through boiling water, allowed to settle for a few minutes, and the supernatant liquid, which contains only the finer particles, is added to the soap bath in such proportion as may be requisite. The silk, on being taken out of this bath, must be wrung well, and stretched upon perches to dry; after which it is introduced into the sulphuring chamber, if it is to be made use of in the white state. At Lyons, however, no soap is employed at the third operation: after the boil, the silk is washed, sulphured, and azured, by passing through very clear river water properly blued.

The silks intended for the manufacture of blonds and gauzes are not subjected to the ordinary scouring process, because it is essential, in these cases, for them to preserve their natural stiffness. We must therefore select the raw silk of China, or the whitest raw silks of other countries; steep them, rinse them in a bath of pure water, or in one containing a little soap; wring them, expose them to the vapor of sulphur, and then pass them through the azure water. Sometimes this process is repeated.

Before the memoir of M. Roard appeared, extremely vague ideas were entertained about the composition of the native varnish of silk. He has shown that this substance, so far from being of a gummy nature, as had been believed, may be rather compared to bees' wax, with a species of oil, and a coloring matter, which exists only in raw silks. It is contained in them to the amount of from 23 to 24 per cent., and forms the portion of weight which is lost in the ungumming. It possesses, however, some of the properties of vegetable gums, though it differs essentially as to others. In a dry mass, it is friable and has a vitreous fracture; it is soluble in water, and affords a solution which lathers like soap; but when thrown upon burning coals, it does not soften like gum, but burns with the exhalation of a fetid odor. Its solution, when left exposed to the open air, at first of a golden yellow, becomes soon greenish, and ere long putrefies, as a solution of animal matter would do in similar circumstances. M. Roard assures us that the city of Lyons alone could furnish several thousand quintals of this substance *per annum*, were it applicable to any useful purpose.

The yellow varnish is of a resinous nature, altogether insoluble in water, very soluble in alcohol, and contains a little volatile oil, which gives it a rank smell. The color of this resin is easily dissipated, either by exposure to the sun or by the action of chlorine: it forms about one fifty-fifth of its weight.

Bees' wax exists also in all the sorts of silk, even in that of China; but the whiter the filaments, the less wax do they contain.

M. Roard has observed that, if the silk be exposed to the soap baths for some time after it has been stripped of its foreign matters, it begins to lose body, and has its valuable qualities impaired. It becomes dull, stiff, and colored in consequence of the solution more or less considerable of its substance; a solution which takes place in all liquids, and even in boiling water. It is for this reason that silks cannot be alumed with heat; and that they lose some of their lustre in being dyed brown, a color which requires a boiling hot bath. The best mode, therefore, of avoiding these inconveniences, is to boil the silks in the soap-bath no longer than is absolutely necessary for the scouring process, and to expose them in the various dyeing operations to as moderate temperature as may be requisite to communicate the color. When silks are to be dyed, much less soap should be used in the cleansing, and very little for the dark colors. According to M. Roard, raw silks, white or yellow, may be completely scoured in one hour, with 15 lbs. of water for one of silk, and a suitable proportion of soap. The soap and the silk should be put into the bath half an hour before its ebullition, and the latter should be turned about frequently. The dull silks, in which the varnish has already undergone some alteration, never acquire a fine white until they are exposed to sulphureous acid gas. Exposure to light has also a very good effect in whitening silks, and is had recourse to, it is said, with advantage by the Chinese.

Carbonate of soda has been proposed to be used instead of soap in scouring silk, but it has never come into use. The Abbé Collomb, in 1785, scoured silk by eight hours' boiling in simple water, and he found the silks bleached in this way to be stronger than by soap, but they are not nearly so white. A patent has been taken out in England for bleaching them by steam, of which an account will be found under the article Silk.

It appears that the Chinese do not use soap in producing those fine white silks which are imported into Europe. Michel de Grubbens, who resided long at Canton, saw and

practised himself the operation there, which he published in the Memoirs of the Academy of Stockholm in 1803. It consists in preparing the silk with a species of white beans, smaller than the Turkey beans, with some wheat flour, common salt, and water. The proportions are 5 parts of beans, 5 of salt, 6 of flour, and 25 of water, to form this vegetable bath. The beans must be previously washed. It is difficult to discover what chemical action can occur between that decoction and the varnish of raw silk; possibly some acid may be developed, which may soften the gummy matter, and facilitate its separation.

Baumé contrived a process which does not appear to have received the sanction of experience, but which may put us in the right way. He macerates the yellow raw silk in a mixture of alcohol at 36° (sp. gr. 0837) and one thirty-second part of pure muriatic acid. At the end of forty-eight hours, it is as white as possible, and the more so, the better the quality of the silk. The loss which it suffers in this menstruum is only one fortieth; showing that nothing but the coloring matter is abstracted. The expense of this menstruum is the great obstacle to Baume's process. The alcohol, however, might be in a very great measure recovered, by saturating the acid with chalk, and redistillation.

Bleaching of Wool.—Wool, like the preceding fibrous matter, is covered with a peculiar varnish, which impairs its qualities, and prevents it from being employed in the raw state for the purposes to which it is well adapted when it is scoured. The English give the name *yolk*, and the French *suint*, to that native coat: it is a fatty unctuous matter, of a strong smell, which apparently has its chief origin in the cutaneous perspiration of the sheep; but which, by the agency of external bodies, may have undergone some changes which modify its constitution. It results from the experiments of M. Vauquelin, that the *yolk* is composed of several substances; namely, 1, a soap with basis of potash, which constitutes the greater part of it; 2, of a notable quantity of acetate of potash; 3, of a small quantity of carbonate, and a trace of muriate, of potash; 4, of a little lime in an unknown state of combination; 5, of a species of sebaceous matter, and an animal substance to which the odor is due. There are several other accidental matters present on sheeps' wool.

The proportion of yolk is variable in different kinds of wool, but in general it is more abundant the finer the staple; the loss by scouring being 45 per cent. for the finest wools, and 35 per cent. for the coarse.

The yolk, on account of its soapy nature, dissolves readily in water, with the exception of a little free fatty matter, which easily separates from the filaments, and remains floating in the liquor. It would thence appear sufficient to expose the wools to simple washing in a stream of water; yet experience shows that this method never answers so well as that usually adopted, which consists in steeping the wool for some time in simple warm water, or in warm water mixed with a fourth of stale urine. From 15 to 20 minutes of contact are sufficient in this case, if we heat the bath as warm as the hand can bear it, and stir it well with a rod. At the end of this time the wool may be taken out, set to drain, then placed in large baskets, in order to be completely rinsed in a stream of water.

It is generally supposed that putrid urine acts on the wool by the ammonia which it contains, and that this serves to saponify the remainder of the fatty matter not combined with the potash. M. Vauquelin is not of this opinion, because he found that wool steeped in water, with sal ammoniac and quick lime, is not better scoured than an equal quantity of wool treated with mere water. He was hence led to conclude that the good effects of putrefied urine might be ascribed to anything else besides the ammonia, and probably to the urea. Fresh urine contains a free acid, which, by decomposing the potash soap of the yolk, counteracts the scouring operation.

If wools are better scoured in a small quantity of water than in a great stream, we can conceive that this circumstance must depend upon the nature of the yolk, which, in a concentrated solution, acts like a saponaceous compound, and thus contributes to remove the free fatty particles which adhere to the filaments. It should also be observed that too long a continuance of the wool in the yolk water, hurts its quality very much, by weakening its cohesion, causing the filaments to swell, and even to split. It is said then to have lost its *nerve.* Another circumstance in the scouring of wool, that should always be attended to, is never to work the filaments together to such a degree as to occasion their felting; but in agitating we must merely push them slowly round in the vessel, or press them gently under the feet. Were it at all felted, it would neither card nor spin well

As the heat of boiling water is apt to decompose woollen fibres, we should be careful never to raise the temperature of the scouring bath to near this point, nor, in fact, to exceed 140° F. Some authors recommend the use of alkaline or soapy baths for scouring wool, but practical people do not deviate from the method above described.

When the washing is completed, all the wool which is to be sent white into the mar-

ket, must be exposed to the action of sulphurous acid, either in a liquid or a gaseous state. In the latter case, sulphur is burned in a close chamber, in which the wools are hung up or spread out; in the former, the wools are plunged into water, moderately impregnated with the acid. (See SULPHURING.) Exposure on the grass may also contribute to the bleaching of wool. Some fraudulent dealers are accused of dipping wools in butter-milk, or chalk and water, in order to whiten them and increase their weight.

Wool is sometimes whitened in the fleece, and sometimes in the state of yarn; the latter affording the best means of operating. It has been observed that the wool cut from certain parts of the sheep, especially from the groins, never bleaches well.

After sulphuring, the wool has a harsh crispy feel, which may be removed by a weak soap bath. To this also the wool comber has recourse when he wishes to cleanse and whiten his wools to the utmost. He generally uses a soft or potash soap, and after the wool is well soaked in the warm soap bath, with gentle pressure he wrings it well with the help of a hook, fixed at the end of his washing tub, and hangs it up to dry.

Bleaching of rags, and paste for paper making. — After the rags are reduced to what is called half stuff, they should have the greater part of the floating water run off, leaving just enough to form a stir-about mass. Into this a clear solution of chloride of lime should be poured, of such a strength as is suited to the color of the rags, which should have been previously sorted; and the engine is kept going so as to churn the rags with the bleaching agent. After an hour, the water may be returned upon the engine, and the washing of the paper resumed. From two to four pounds of good chloride of lime are reckoned sufficient to bleach one hundred weight of rags.

When the rags consist of dyed or printed cottons, after being well washed and reduced to half stuff, they should be put into a large cask or butt, supported horizontally by iron axles upon cradle bearings, so that it may be made to revolve like a barrel-churn. For each hundred weight of the colored rags, take a solution containing from four to eight pounds of chloride of lime; add it to the liquid mixture in the butt along with half a pound of sulphuric acid for every pound of the chloride; and after inserting the bung, or rather the square valve, set the vessel in slow revolution backwards and forwards. In a short time the rags will be colorless. The rags and paper paste ought to be very well washed, to expel all the chlorine, and perhaps a little muriatic acid might be used with advantage to dissolve out all the calcareous matter, a portion of which is apt to remain in the paper, and to operate injuriously upon both the pens and the ink. Some of the French paper manufacturers bleach the paste with chlorine gas. Paper prepared from such paste, well washed, is not apt to give a brown tint to maps, as that carelessly bleached with chloride of lime is known to do.

BLENDE. (*Fr. and Germ.*) Sulphuret of zinc, so named from the German *blenden*, to dazzle, on account of its glistening aspect. It is called black jack from its usual color. Its lustre is pearly adamantine. Spec. gravity from 3·7 to 4·2. It contains frequently iron, copper, arsenic, cadmium, and silver, all associated with sulphur. It is worked up partly into metallic zinc, and partly into the sulphate of zinc, or white vitriol. It consists of 66·72 zinc, and 33·28 sulphur; being nearly by weight as two to one. See ZINC.

BLOCK MANUFACTURE. Though the making of ships' blocks belongs rather to a dictionary of engineering than of manufactures, it may be expected that I should give some account of the automatic machinery for making blocks so admirably devised and mounted by M. L. Brunel, Esq. for the British navy, in the dock-yard of Portsmouth.

The series of machines and operations are as follows: —

1. *The straight cross-cutting saw.*—The log is placed horizontally on a very low bench, which is continued through the window of the mill into the yard. The saw is exactly over the place where the log is to be divided. It is let down, and suffered to rest with its teeth upon the log, the back still being in the cleft of the guide. The crank being set in motion, the saw reciprocates backwards and forwards with exactly the same motion as if worked by a carpenter, and quickly cuts through the tree. When it first begins to cut, its back is in the cleft in the guide, and this causes it to move in a straight line; but before it gets out of the guide, it is so deep in the wood as to guide itself: for in cutting across the grain of the wood, it has no tendency to be diverted from its true line by the irregular grain. When the saw has descended through the tree, its handle is caught in a fixed stop, to prevent its cutting the bench. The machine is thrown out of gear, the attendant lifts up the saw by a rope, removes the block cut off, and advances the tree to receive a fresh cut.

2. *The circular cross-cutting saw.*—This saw possesses universal motion; but the axis is always parallel to itself, and the saw in the same plane. It can be readily raised or lowered, by inclining the upper frame on its axis; and to move it sidewise, the saw frame must swing sidewise on its joints, which connect it with the upper frame. These movements are effected by two winches, each furnished with a pair of equal pinions, working a pair of racks fixed upon two long poles. The spindles of these winches are fixed in two

vertical posts, which support the axis of the upper frame.   One of these pairs of poles is jointed to the extreme end of the upper frame; therefore by turning the handle belonging to them, the frame and saw is elevated or depressed; in like manner, the other pair is attached to the lower part of the saw frame, so that the saw can be moved sidewise by means of their handles, which then swing the saw from its vertical position.

These two handles give the attendant a complete command of the saw, which we suppose to be in rapid motion, the tree being brought forward and properly fixed. By one handle, he draws the saw against one side of the tree, which is thus cut into (perhaps half through); now, by the other handle, he raises the saw up, and by the first-mentioned handle he draws it across the top of the tree, and cuts it half through from the upper side; he then depresses the saw and cuts half through from the next side; and lastly a trifling cut of the saw, at the lower side, completely divides the tree, which is then advanced to take another cut.

The great reciprocating saw is on the same principle as the saw-mill in common use in America.

3. *The circular ripping saw* is a thin circular plate of steel, with teeth similar to those of a pit saw, formed in its periphery.   It is fixed to a spindle placed horizontally, at a small distance beneath the surface of a bench or table, so that the saw projects through a crevice a few inches above the bench.   The spindle, being supported in proper collars, has a rapid rotatory motion communicated to it by a pulley on the opposite end, round which an endless strap is passed from a drum placed overhead in the mill.   The block cut by the preceding machine, from the end of the tree, is placed with one of the sides flat upon the bench, and thus slides forward against the revolving saw, which cuts the wood with a rapidity incredible to any one who has not seen these or similar machines.

4. *Boring machine.*—The blocks, prepared by the foregoing saws, are placed in the machine represented in *fig.* 131.   This machine has an iron frame, A A, with three legs,
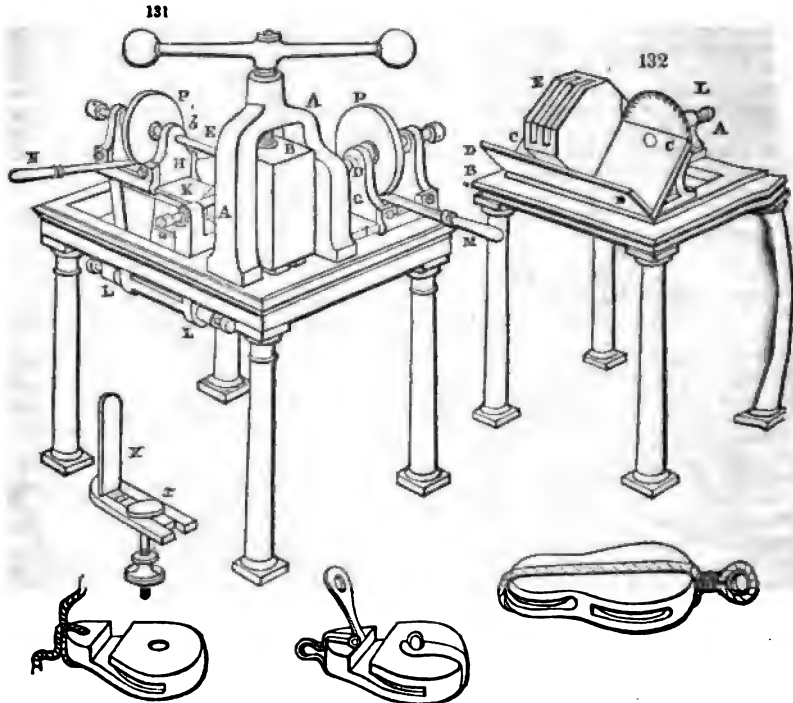
beneath which the block is introduced, and the screw near B being forced down upon it, confines it precisely in the proper spot to receive the borers D and E.   This spot is determined by a piece of metal fixed perpendicularly just beneath the point of the borer E, shown separately on the ground at x; this piece of metal adjusts the position for the borer D, and its height is regulated by resting on the head of the screw x, which fastens the piece x down to the frame.   The sides of the block are kept in a parallel position, by being applied against the heads of three screws tapped into the double leg of the frame

4. The borer D is adapted to bore the hole for the centre pin in a direction exactly perpendicular to the surface resting against the three screws; the other, at E, perforates the holes for the commencement of the sheave holes. Both borers are constructed in nearly the same manner; they are screwed upon the ends of small mandrels, mounted in frames similar to a lathe. These frames, G and H, are fitted with sliders upon the angular edges of the flat broad bars, I and K. The former of these is screwed fast to the frame; the latter is fixed upon a frame of its own, moving on the centre screws, at L L, beneath the principal frame of the machine. By this means the borer E can be moved within certain limits, so as to bore holes in different positions. These limits are determined by two screws, one of which is seen at a; the other, being on the opposite side, is invisible. They are tapped through fixed pieces projecting up from the frame. A projecting piece of metal, from the under side of the slider K of the borer E, stops against the ends of these screws, to limit the excursion of the borer. The frames for both borers are brought up towards the block by means of levers M and N. These are centred on a pin, at the opposite sides of the frame of the machine, and have oblong grooves through them, which receive screw pins, fixed into the frames G and H, beneath the pulleys P P, which give motion to the spindles.

5. *The mortising machine* is a beautiful piece of mechanism, but too complicated for description within the limits prescribed to this article.

6. *The corner saw*, fig. 132, consists of a mandrel, mounted in a frame A, and carrying a circular saw L upon the extreme end of it. This mandrel and its frame being exactly similar to those at G and H, fig. 131, does not require a separate view, although it is hid behind the saw, except the end of the screw, marked A. This frame is screwed down upon the frame B B of the machine, which is supported upon four columns. c c, D D, is an inclined bench, or a kind of trough, in which a block is laid, as at E, being supported on its edge by the plane c c of this bench, and its end kept up to its position by the other part of the bench D D.

By sliding this bench along it, it is applied to the saw, which cuts off its angles, as is evident from the figure, and prepares it for the shaping engine. All the four angles are cut off in succession, by applying its different sides to the trough, or bench. In the figure, two of them are drawn as being cut, and the third is just marked by the saw. This machine is readily adapted to different sizes of blocks, by the simple expedient of laying pieces of wood of different thickness against the plane D D, so as to fill it up, and keep the block nearer to or farther from the saw; for all the blocks are required to be cut at the same angle, though, of course, a larger piece is to be cut from large than from small blocks. The block reduced to the state of E is now taken to
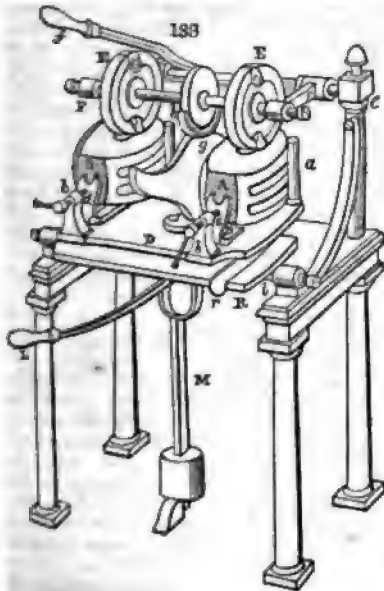
7. *The shaping machine.*—A great deal of the apparent complication of this figure arises from the iron cage, which is provided to defend the workmen, lest the blocks, which are revolving in the circles, or chuck, with an immense velocity, should be loosened by the action of the tool, and fly out by their centrifugal force. Without this provision, the consequences of such an accident would be dreadful, as the blocks would be projected in all directions, with an inconceivable force.

8. *The scoring engine* receives two blocks, as they come from the shaping engine, and forms the groove round their longest diameters for the reception of their ropes or straps, as represented in the two snatch blocks and double block, under *figs.* 131, 132.

A, B, *fig.* 133, represent the above two blocks, each held between two small pillars a (the other pillar is hid behind the block), fixed in a strong plate D, and pressed against the pillars by a screw b, which acts on a clamp d. Over the blocks a pair of circular planes or cutters, E E, are situated, both being fixed on the same spindle, which is turned by a pulley in the middle of it. The spindle is fitted in a frame F F, moving in centres at e e, so

as to rise and fall when moved by a handle *f*. This brings the cutters down upon the blocks; and the depth to which they can cut is regulated by a curved shape *g*, fixed by screws upon the plate D, between the blocks. Upon this rests a curved piece of metal *h*, fixed to the frame F, and enclosing, but not touching, the pulley. To admit the cutters to traverse the whole length of the blocks, the plate D (or rather a frame beneath it) is sustained between the points of two centres. Screws are seen at *l*, on these centres. The frame inclines when the handle L is depressed. At M is a lever, with a weight at the end of it, counterbalancing the weight of the blocks, and plate D, all which are above the centre on which they move. The frame F is also provided with a counterpoise to balance the cutters, &c. The cutters E E are circular wheels of brass, with round edges. Each has two notches in its circumference, at opposite sides; and in these notches chisels are fixed by screws, to project beyond the rim of the wheel, in the manner of a plane iron before its face.

This machine is used as follows:—In order to fix the block, it is pressed between the two pins (only one of which at *a*, can be seen in this view), and the clamp *d*, screwed up against it, so as just to hold the block, but no more. The clamp has two claws, as is seen in the figure, each furnished with a ring entering the double prints previously made, in the end of the block. These rings are partly cut away, leaving only such a segment of each as will just retain the block, and the metal between them is taken out to admit the cutter to operate between them, or nearly so. In putting the blocks into this machine, the workman applies the double prints to the ends of the claws of the clamps, but takes care that the blocks are higher between the pins *a* than they should be: he then takes the handle *f*, and by it presses the cutters E E (which we suppose are standing still) down upon the blocks, depressing them between their pins at the same time, till the descent of the cutters is stopped by the piece *h* resting on the shape *g*. He now turns the screws *b b*, to fix the blocks tight. The cutters being put in motion cut the scores, which will be plainly seen by the mode of adjustment just described, to be of no depth at the pin-hole; but by depressing the handle L, so as to incline the blocks, and keeping the cutters down upon their shape *g*, by the handle *f*, they will cut any depth towards the ends of the blocks, which the shape *g* admits.
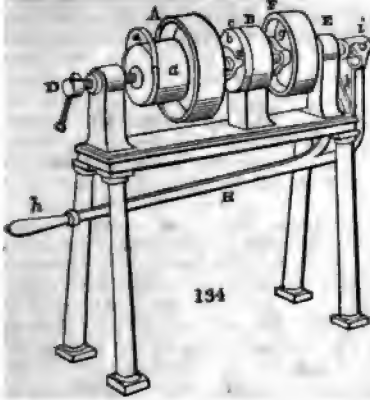
By this means one quarter of the score is formed; the other is done by turning both blocks together half round in this manner. The centres *l* are not fitted into the plate itself, but into a frame seen at R beneath the plate, which is connected with it by a centre pin, exactly midway between the two blocks A B. A spring catch, the end of which is seen at *r*, confines them together; when this catch is pressed back, the plate can be turned about upon its centre pin, so as to change the blocks, end for end, and bring the unscored quarters (*i. e.* over the clamps) beneath the cutters; the workman taking the handles *f* and L, one in each hand, and pressing them down, cuts out the second quarter. This might have been effected by simply lifting up the handle L; but in that case the cutter would have struck against the grain of the wood, so as to cut rather roughly; but by this ingenious device of reversing the blocks, it always cuts clean and smooth, in the direction of the grain. The third and fourth quarters of the score are cut by turning the other sides of the blocks upwards, and repeating the above operation. The shape *g* can be removed, and another put in its place, for different sizes and curves of block; but the same pins *a*, and holding clamps *d*, will suit many different sizes.

By these machines the shells of the blocks are completely formed, and they are next polished and finished by hand labor; but as this is performed by tools and methods which are well known, it is needless to enter into any explanation: the finishing required being only a smoothing of the surfaces. The machines cut so perfectly true as to require no wood to be removed in the finishing; but as they cut without regard to the irregularity of the grain, knots, &c., it happens that many parts are not so smooth as might be wished, and for this purpose manual labor alone can be employed.

The lignum vitæ for the sheaves of the blocks, is cut across the grain of the wood by two cross-cutting saws, a circular and straight saw, as before mentioned. These machines do not essentially differ in their principle from the great cross-cutting saws we have described, except that the wood revolves while it is cutting, so that a small saw will reach the centre of a large tree, and at the same time cut it truly flat. The limits prescribed for our plates will not admit of giving drawings of these machines, and the idea which could be derived from a verbal description would not be materially different from the cross-cutting saws before mentioned. These machines cut off their plates for the end of the tree, which are exactly the thickness for the intended sheave. These pieces are of an irregular figure, and must be rounded and centred in the crown saw.

9. *The crown saw* is represented in *fig.* 134, where A is a pulley revolving by means of an endless strap. It has the crown or trepan saw *a* fixed to it, by a screw cut within the piece, upon which the saw is fixed, and which gives the ring or hoop of the

saw sufficient stability to perform its office. Both the pulleys and saw revolve together upon a truly cylindrical tube *b*, which is stationary, being attached by a flaunch *c* to a fixed puppet B, and on this tube as an axis the saw and pulley turn, and may be slid endwise by a collar fitted round the centre-piece of the pulley, and having two iron rods (only one of which can be seen at *d* in the figure), passing through holes made through the flaunch and puppet B. When the saw is drawn back upon its central tube, the end of the latter projects beyond the teeth of the saw. It is by means of this fixed ring or tube within the saw, that the piece of wood *e* is supported during the operation of sawing, being pressed forcibly against it by a screw D, acting through a puppet fixed to the frame of the machine. At the end of this screw is a cup or basin which applies itself to the piece of wood, so as to form a kind of vice, one side being the end of the fixed tube, the other the cup at the end of the screw D. Within the tube *b* is a collar for supporting a central axis, which is perfectly cylindrical. The other end of this axis, (seen at *f*,) turns in a collar of the fixed puppet E. The central axis has a pulley F, fixed on it, and giving it motion by a strap similar to the other. Close to the latter pulley a collar *g* is fitted on the centre piece of the pulley, so as to slip round freely, but at the same time confined to move endways with the pulley and its collar. This collar receives the ends of the two iron rods *d*. The opposite ends of these rods are, as above mentioned, connected by a similar collar, with the pulley A of the saw *a*. By this connexion, both the centre bit, which is screwed into the end of the central axis *f*, and the saw sliding upon the fixed tube *b*, are brought forward to the wood at the same time, both being in rapid motion by their respective pulleys.

10. *The Coaking Engine.*—This ingenious piece of machinery is used to cut the three semicircular holes which surround the hole bored by the crown saw, so as to produce a cavity in the centre of the disc.

11. *Face-turning Lathe.*—The sheave is fixed against a flat chuck at the end of a mandrel, by a universal chuck, similar to that in the coaking engine, except that the centre pin, instead of having a nut, is tapped into the flat chuck, and turned by a screw-driver.

BLOOD. (*Sang*, Fr.; *Blut*, Germ.) The liquid which circulates in the arteries and veins of animals; bright red in the former and purple in the latter, among all the tribes whose temperature is considerably higher than that of the atmosphere. It consists, 1. of a colorless transparent solution of several substances in water; and, 2. of red, undissolved particles diffused through that solution. Its specific gravity varies with the nature and health of the animal; being from 1·0527 to 1·0570 at 60° F. It has a saline sub-nauseous taste, and a smell peculiar to each animal. When fresh drawn from the vessels, it rapidly coagulates into a gelatinous mass, called the clot, cruor, or crassamentum, from which, after some time, a pale yellow fluid, passing into yellowish green, oozes forth, called the serum. If the warm blood be stirred with a bundle of twigs, as it flows from the veins, the fibrine concretes, and forms long fibres and knots, while it retains its usual appearance in other respects. The clot contains fibrine and coloring matter in various proportions. Berzelius found in 100 parts of the dried clot of blood, 35 parts of fibrine; 58 of coloring matter; 1·3 of carbonate of soda; 4 of an animal matter soluble in water, along with some salts and fat. The specific gravity of the serum varies from 1·027 to 1·029. It forms about three fourths of the weight of the blood, has an alkaline reaction, coagulates at 167° F. into a gelatinous mass, and has for its leading constituent *albumen* to the amount of 8 per cent, besides fat, potash, soda, and salts of these bases. Blood does not seem to contain any gelatine.

The red coloring matter called *hematine*, may be obtained from the cruor by washing with cold water and filtering.

Blood was at one time largely employed for clarifying sirup, but it is very sparingly used by the sugar refiners in Great Britain of the present day. It may be dried by evaporation at a heat of 130° or 140°, and in this state has been transported to the colonies for purifying cane juice. It is an ingredient in certain adhesive cements, coarse pigments for protecting walls from the weather, for making animal charcoal in the Prussian blue works, and by an after process, a decoloring carbon. It is used in some Turkey red dye-works. Blood is a powerful manure.

BLOWING MACHINE. See Iron, Metallurgy, Ventilation.

BLOWPIPE. (*Chalumeau*, Fr.; *Lothröhre*, Germ.) Jewellers, mineralogists, chemists, enamellers, &c., make frequent use of a tube, usually bent near the end, terminated with a finely pointed nozzle, for blowing through the flame of a lamp, candle, or gas-jet, and producing thereby a small conical flame possessing a very intense heat. Modifications of blow pipes are made with jets of hydrogen, oxygen, or the two gases mixed in due proportions.

BLUE DYES. (*Teint*, Germ. See Enamel.) The materials employed for this purpose are indigo, Prussian blue, logwood, bilberry, (*vaccinium myrtillus*,) elder berries, (*sambucus nigra*,) mulberries, privet berries, (*ligustrum vulgare*,) and some other berries whose juice becomes blue by the addition of a small portion of alkali, or of the salts of copper. For dyeing with the first three articles, see them in their alphabetical places. I shall here describe the other or minor blue dyes.

To dye blue with such berries as the above, we boil one pound of them in water, adding one ounce of alum, of copperas, and of blue vitriol, to the decoction, or in their stead equal parts of verdigris and tartar, and pass the stuffs a sufficient time through the liquor. When an iron mordant alone is employed, a steel blue tint is obtained; and when a tin one, a blue with a violet cast. The privet berries which have been employed as sap colors by the card painters, may be extensively used in the dyeing of silk. The berries of the African night-shade (*solanum guineense*) have been of late years considerably applied to silk on the continent in producing various shades of blue, violet, red, brown, &c., but particularly violet. With alkalis and acids these berries have the same habitudes as bilberries; the former turning them green, the latter red. They usually come from Italy compressed in a dry cake, and are infused in hot water. The infusion is merely filtered, and then employed without any mordant, for dyeing silk, being kept at a warm temperature by surrounding the bath vessel with hot water. The goods must be winced for six hours through it in order to be saturated with color; then they are to be rinsed in running water and dried. One pound of silk requires a pound and a half of the berry cake. In the residuary bath, other tints of blue may be given. Sometimes the dyed silk is finished by running it through a weak alum water. A color approaching to indigo in permanence, but which differs from it in being soluble in alkalis, though incapable of similar disoxydizement, is the *gardenia genipa* and *aculeata* of South America, whose colorless juice becomes dark blue with contact of air; and dyes stuffs, the skin, and nails, of an unchangeable deep blue color, but the juice must be applied in the colorless state.

BLUE PIGMENTS. Several metallic compounds possess a blue color; especially those of iron, cobalt, and molybdenum. The metallic pigments, little if at all employed, but which may be found useful in particular cases, are the molybdate of mercury, the hydro-sulphuret of tungsten, the prussiate of tungsten, the molybdate of tin, the oxyde of copper darkened with ammonia, the silicate of copper, and a fine violet color formed from manganese and molybdenum. The blues of vegetable origin, in common use, are indigo, litmus, and blue cakes. The blue pigments of a metallic nature found in commerce are the following: *Prussian blue*; *mountain blue*, a carbonate of copper mixed with more or less earthy matter; *Bremen blue* or *verditer*, a greenish blue color obtained from copper mixed with chalk or lime; *iron blue*, phosphate of iron, little employed; *cobalt blue*, a color obtained by calcining a salt of cobalt with alumina or oxyde of tin; *smalt*, a glass colored with cobalt and ground to a fine powder; *charcoal blue*, a deep shade obtained by triturating carbonized vine stalks with an equal weight of potash in a crucible till the mixture ceases to swell, then pouring it upon a slab, putting it into water, and saturating the alkali with sulphuric acid. The liquor becomes blue, and lets fall a dark blue precipitate, which becomes of a brilliant blue color when heated.

Molybdenum blue is a combination of this metal, and oxyde of tin or phosphate of lime. It is employed both as a paint, and an enamel color. A blue may also be obtained by putting into molybdic acid, (made by digesting sulphuret of molybdenum with nitric acid,) some filings of tin, and a little muriatic acid. The tin deoxydizes the molybdic acid to a certain degree, and converts it into the molybdous, which, when evaporated and heated with alumina recently precipitated, forms this blue pigment. *Ultramarine* is a beautiful blue pigment, which see.

BLUE VITRIOL; sulphate of copper.

BOMBAZINE. A worsted stuff, sometimes mixed with silk.

BONES. (*Os*, Fr.; *Knochen*, Germ.) They form the frame work of animal bodies, commonly called the skeleton; upon which the soft parts are suspended, or in which they are enclosed. Bones are invested with a membrane styled the periosteum, which is composed of a dense tissue affording glue; whence it is convertible into jelly, by ebullition with water. Bones are not equally compact throughout their whole substance; the long ones have tubes in their centres lined with a kind of periosteum, of more importance to the life of the bones than even their external coat. The flat, as

well as the short and thick bones, exhibit upon their surface an osseous mass of a dense nature, while their interior presents a cavity divided into small cellules by their bony partitions.

In reference to the composition of bones, we have to consider two principal constituents; the living portion or the osseous cartilage, and the inorganic or the earthy salts of the bones.

The osseous cartilage is obtained by suspending bones in a large vessel full of dilute muriatic acid, and leaving it in a cool place at about 50° Fahr. for example. The acid dissolves the earthy salts of the bones without perceptibly attacking the cartilage, which, at the end of a short time, becomes soft and translucid, retaining the shape of the bones; whenever the acid is saturated, before it has dissolved all the earthy salts it should be renewed. The cartilage is to be next suspended in cold water, which is to be frequently changed till it has removed all the acidity. By drying, the cartilage shrinks a little, and assumes a darker hue, but without losing its translucency. It becomes, at the same time, hard and susceptible of breaking when bent, but it possesses great strength.

This cartilage is composed entirely of a tissue passing into gelatine. By boiling with water, it is very readily convertible into a glue, which passes clear and colorless through the filter, leaving only a small portion of fibrous matter insoluble by further boiling. This matter is produced by the vessels which penetrate the cartilage, and carry nourishment to the bone. We may observe all these phenomena in a very instructive manner, by macerating a bone in dilute muriatic acid, till it has lost about the half of its salts; then washing it with cold water, next pouring boiling water upon it, leaving the whole in repose for 24 hours, at a temperature a few degrees below 212° Fahr.

The cartilage, which has been stripped of its earthy salts, dissolves, but the small vessels which issue from the undecomposed portion of the bone remain under the form of white plumes, if the water has received no movement capable of crushing or breaking them. We may then easily recognise them with a lens, but the slightest touch tears them, and makes them fall to the bottom of the vessel in the form of a precipitate; if we digest bones with strong hot muriatic acid so as to accelerate their decomposition, a portion of the cartilage dissolves in the acid with a manifest disengagement of carbonic acid gas, which breaks the interior mass, and causes the half-softened bone to begin to split into fibrous plates, separable in the direction of their length. According to Marx, these plates, when sufficiently thin, possess, like scales of mica, the property of polarizing light, a phenomenon which becomes more beautiful still when we soak them with the essential oil of the bark of the Laurus Cassia. The osseous cartilage is formed before the earthy part. The long bones are then solid, and they become hollow only in proportion as the earthy salts appear. In the new-born infant, a large portion of the bones is but partially filled with these salts, their deposition in cartilage takes place under certain invariable *points of ossification*, and begins at a certain period after conception, so that we may calculate the age of the foetus according to the progress which ossification has made.

The earthy parts of bones are composed principally of the phosphate and carbonate of lime in various proportions, variable in different animals, and mixed with small quantities, equally variable, of phosphate of magnesia and fluate of lime. The easiest means of procuring the earthy salts of bones consists in burning them to whiteness, but the earthy residuum procured in this manner, contains substances which did not exist beforehand in the bones, and which did not form a part of their earthy salts; as, for example, sulphate of soda, produced at the expense of the sulphur of the bones and the alkaline carbonate, proceeding from the cartilage with which it was combined. On the other hand, the greater part of the lime has lost its carbonic acid. As the sulphuric acid is the product of combustion, it is obvious that an acidulous solution of a fresh bone can afford no precipitate with muriate of barytes. The phosphate of lime contained in the bone-salts is a subphosphate, consisting, according to Berzelius, of three prime equivalents of the acid, and eight of the base; or of 2,677 parts of the former, and 2,848 of the latter. It is always obtained when we precipitate the phosphate of lime by an excess of ammonia. When calcined bones are distilled in a retort with their own weight of sulphuric acid, a little fluoric acid is disengaged, and it acts on the surface of the glass. The following analyses of the bones of men and horned cattle, are given by Berzelius. They were dried after being stripped of their fat and periosteum till they lost no more weight.

	Human bone.	Ox bone.
Cartilage completely soluble in water - - - -	32·17 }	33·3
Vessels - - - - - - - - - - -	1·13 }	
Subphosphate with a little fluate of lime - - - -	53·04	57·35
Carbonate of lime - - - - - - - - -	11·3	3·65
Phosphate of magnesia - - - - - - - -	1·16	2·05
Soda with very little muriate of soda - - - -	1·20	3·45
	100·00	100·00

The most essential difference in the composition of these bones is that those of man contain three times as much carbonate of lime as those of the ox; and that the latter are richer in phosphate of lime and magnesia in the same proportion. Fernandez de Barros has established a comparison between the phosphate and carbonate of lime in the bones of different animals. He found in 100 parts of earthy salt of the bones of the following animals:—

	Phosphate of lime	Carb. lime
Lion - - - - - - - - - - -	95·0	2·5
Sheep - - - - - - - - - - -	80·0	19·3
Hen - - - - - - - - - - -	83·9	10·4
Frog - - - - - - - - - - -	95·2	2·4
Fish - - - - - - - - - - -	91·9	5·3

The bones of fish are divided into those which contain earthy salts and those which have none, called cartilaginous fishes. The enamel of the teeth is composed as follows:—

	Human enamel.	Ox enamel.
Phosphate of lime with fluate of lime - - - -	88·5	85·0
Carbonate of lime - - - - - - - -	8·0	7·1
Phosphate of magnesia - - - - - - -	1·5	3·0
Soda - - - - - - - - - - -	0·0	1·4
Brown membranes attached to the tooth, alkali, water -	2·0	3·5
	100·0	100·0

In the arts, the bones are employed by turners, cutlers, manufacturers of animal charcoal, and, when calcined, by assayers for making cupels. In agriculture, they are employed as a manure, for which purpose they should be ground in a mill, and the powder sowed along with the seeds in a drill. It is supposed, in many cases, to increase the crop in weight of grain and straw together, by from 40 to 50 per cent. In France, soup is extensively made by dissolving bones in a steam-heat of two or three days' continuance. The shavings of hartshorn, which is a species of bone, afford an elegant jelly; the shavings of calves' bones may be used in their stead.

Living bones acquire a red tinge when the animals receive madder with their food; but they lose it when the madder is discontinued for some time.

BONE BLACK (Noir d'os, Fr.; Knochenschwartz, Germ.), or Animal charcoal, as it is less correctly called, is the black carbonaceous substance into which bones are converted by calcination in close vessels. This kind of charcaol has two principal applications: to deprive various solutions, particularly sirups, of their coloring matters, and to furnish a black pigment. The latter subject will be treated of under Ivory Black.

The discovery of the antiputrescent and decoloring properties of charcoal in general, is due to Lowitz, of Petersburg; but their modifications have occupied the attention of many chemists since his time. Kels published, in 1798, some essays on the discoloring of indigo, saffron, madder, sirup, &c. by means of charcoal, but he committed a mistake in supposing bone black to have less power than the charcoal of wood. The first useful application of charcoal to the purification of raw colonial sugar was made by M. Guillon, who brought into the French markets considerable quantities of fine sirups, which he discolored by ground wood charcoal, and sold them to great advantage, as much superior to the cassonades of that time. In 1811, M. Figuier, an apothecary at Montpelier, published a note about animal charcoal, showing that it blanched vinegars and wines with much more energy than vegetable charcoal; and, lastly, in 1812,

M. Deroones proposed to employ animal charcoal in the purification of sirups and sugar refining. The quantities of bone black left in the retorts employed by MM. Payen, for producing crude carbonate of ammonia, furnished abundant materials for making the most satisfactory experiments, and enabled these gentlemen soon to obtain ten per cent. more of refined sugar from the raw article than had been formerly extracted, and to improve, at the same time, the characters of the lumps, bastards, treacle, &c.

The calcination of bones is effected by two different systems of apparatus; by heating them in a retort similar to that in which coal is decomposed in the gas works, or in small pots piled up in a kiln. For the description of the former, see Gas-Light. On the second plan, the bones, broken into pieces, are put into small cast-iron pots of the form shown in *fig*. 135, about three eighths of an inch thick, two of which are dexterously placed with their mouths in contact, and then luted together with loam. The lip of the upper pot is made to slip inside of the under one. These double vessels, containing together about fifty pounds of bones, are arranged alongside, and over each other, in an oven, like a potter's kiln, till it be filled. The oven or kiln may be either oblong or upright. The latter is represented in *figs*. 136, 137, 138. A is the fireplace or grate for the fuel; c c are the openings in the dome of the furnace through which the flame flows; the divisions of these orifices are shown in *fig*. 138. B is the wall of brick-work. D the space in which the pots are distributed. E is the door by which the workman carries in the pots, which is afterwards built up with fire-bricks, and plastered over with loam. This door is seen in *fig*. 136. F F are the lateral flues for conveying the disengaged gases into the air.
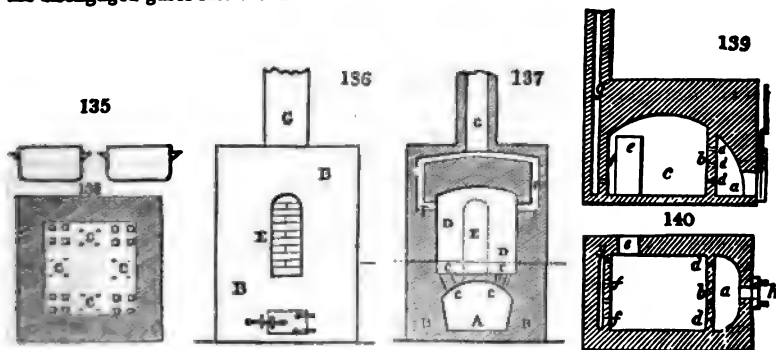

Fig. 139 is a longitudinal section, and *fig*. 140, a ground plan of a horizontal kiln for calcining bones. a is the fire-chamber, lying upon a level with the sole of the kiln; it is separated by a pillar b, from the calcining hearth c. In the pillar or wall, several rows of holes d, are left at different heights; e is the entrance door; f, the outlet vents for the gases, vapors, and smoke, into the chimney g; h, a sliding damper-plate for regulating the admission of the air into the fire in the space a.

By this arrangement the offensive emanations are partly consumed, and partly carried off with the smoke. To destroy the smell completely, the smoke should be made to pass through a second small furnace.

The number of pots that may be put into a kiln of this kind depends, of course, upon its dimensions; but, in general, from 100 to 150 are piled up over each other, in columns, at once; the greatest heat being nearest the roof of the kiln; which resembles, in many respects, that used for baking pottery ware.

In both kilns the interior walls are built of fire-bricks. In the oblong one, the fiercest heat is near the vaulted roof; in the upright one, near the sole; and the pots, containing the larger lumps of bones, should be placed accordingly near the top of the former, and the bottom of the latter. Such a kiln may receive about seventy double pots, containing in the whole thirty-five cwt. of bones.

After the earth is filled with the pots, and the entrance door is shut, the fire is applied at first moderately, but afterwards it must be raised and maintained, at a brisk heat, for eight or ten hours. The door of the ash-pit and the damper may now be nearly closed, to moderate the draught, and to keep up a steady ignition for six or eight hours longer, without additional firing; after which the doors must be all opened to cool the furnace. When this is done, the brick-work of the entrance door must be taken down, the kiln must be emptied, and immediately filled again with a set of pots previously filled with bones, and luted together; the pots which have been ignited may, in the course of a short time, be opened, and the contents put into the magazine. But

in operating with the large decomposing cylinder retort, the bones being raked out hot, must be instantly tossed into a receiver, which can be covered in air-tight till they are cool.

The bones lose upon the average about one half of their weight in the calcination. In reference to the quality of the black, experience has shown that it is so much more powerful as a discoloring agent, as the bones from which it was made have been freer from adhering fatty, fleshy, and tendinous matters.

The charcoal is ground in a mill, either to a fine powder and sifted, or into a coarse granular state, like gunpowder, for the preparation of which two sieves are required, one with moderately fine meshes, to allow the small dust to pass through, and one with large meshes, to separate the proper-sized grains from the coarser lumps. Either a corn-mill, an edgestone mill, or a steel cylinder mill, may be employed for grinding bone-black, and it is generally damped in the operation to keep down the fine dust.

Bone-black, as found in commerce, is very variable in its discoloring power, which arises from its having been exposed either to too great a heat which has glazed its carbon, or too low a heat which has left its albumen imperfectly decomposed. A steady ignition of due continuance is the proper decomposing temperature. Its composition is generally as follows :—

Phosphate of lime, with carbonate of lime, and a little sulphuret of iron, or oxyde of iron, 88 parts; iron in the state of a silicated carburet, 2 parts; charcoal containing about one fifteenth of azote, 10 parts. None of the substances present, except the charcoal, possesses separately any discoloring power.

The quality may be tested by a solution of brown sugar, or molasses, or of indigo in sulphuric acid. The last is generally preferred by the French chemists, who have occupied themselves most with this subject, and it contains usually one thousandth part of its weight of this dye-drug of the best quality. Other animal substances yield a charcoal, possessed of very considerable discoloring properties. The following table by M. Bussy exhibits an interesting comparison of almost every kind of charcoal in this point of view.

Table of the discoloring powers of different charcoals.

Species of Charcoal.	Weight.	Indigo test consumed.	Molasses test consumed.	Blanching by indigo.	Power by molasses.
	Gramme.	Litres.			
Blood calcined with potash	1	1·60	0·18	50	20
Ditto with chalk - - -	1	0·57	0·10	18	11
Ditto with phosphate lime	1	0·38	0·09	12	10
Gelatine ditto with potash	1	1·15	0·14	36	15·5
Albumen ditto ditto - -	1	1·08	0·14	34	15·5
Starch ditto ditto - - -	1	0·34	0·08	10·6	8·8
Charcoal from acet. potash	1	0·18	0·04	5·6	4·4
Ditto from carb. soda by phosphorus - - - -	1	0·38	0·08	12	8·8
Calcined lamp black - -	1	0·128	0·03	4	3·3
Ditto ditto potash - - -	1	0·55	0·09	15·2	10·6
Bone black treated with mur. acid and potash -	1	1·45	0·18	45	20
Bone black ditto with mur. acid - - - - - -	1	0·06	0·015	1·87	1·6
Oil calcined with phosph. of lime - - - - -	1	0·064	0·017	2	1·9
Crude bone black - - -	1	0·032	0·009	1	1

With regard to the mode of operation of bone black on colored liquids, M. Payen showed in his prize essay, 1. That the decoloring power of charcoal depends in general upon its state of division; 2. That in the various charcoals, the carbonaceous matter acts only upon the coloring matters, combining with and precipitating them; 3. That in the application of charcoal to the refining of sugar, it acts also upon the gluten, for it singularly promotes crystallization; 4. That according to the above principles, the decoloring action of charcoals may be so modified, as to make the most inert become the most active; 5. That the distinction between animal and vegetable charcoals is improper, and that we may substitute for it that of dull and brilliant charcoals; 6. That of the substances present in charcoal besides carbon, and particularly animal charcoal, those which favor the decoloring action, have an influence relative only to the carbon; they serve as auxiliaries to it, by insulating its particles, and presenting them more freely to the action of the coloring matter; 7. That animal charcoal, besides its decoloring power, has the valuable property of taking lime in solution from water and

sirup; 8. That neither vegetable, nor other charcoals, besides the animal, have this power of abstracting lime; 9. That by the aid of the decolorimeter, or graduated tube charged with test solution of indigo or molasses, it is easy to appreciate exactly the de coloring properties of all kinds of charcoal.

Different varieties of lignite (fossilized wood) or even pit coal, when well carbonized in close vessels, afford a decoloring charcoal of considerable value. By reducing 100 parts of clay into a thin paste with water, kneading into it 20 parts of tar, and 500 of finely-ground pit coal, drying the mixed mass, and calcining it out of contact of air, a charcoally matter may be obtained not much inferior to bone-black in whitening sirups.

The restoration of animal charcoal from burnt bones, for the purpose of sugar refining, has been long practised in France. Mr. W. Parker has lately made the following process the subject of a patent. The charcoal, when taken from the vessel in which it has been employed for the purposes of clarifying the sugar, is to be thoroughly washed with the purest water that can be obtained, in order to remove all the saccharine matter adhering to it. When the washing process has been .completed, the charcoal is laid out to dry, either in the open air or in a suitable stove, and when perfectly free from moisture, it is to be separated into small pieces and sifted through a sieve, the wires or meshes of which are placed at distances of about two and a half in every inch. This sifting will not only divide the charcoal into small pieces, but will cause any bits of wood or other improper matters to be separated from it.

The charcoal, thus prepared, is then to be packed lightly in cylindrical vessels called crucibles, with some small quantity of bones, oil, or other animal matter mixed with it. The crucibles are then to be closed by covers, and luted at the joints, leaving no other opening but one small hole in the centre of the cover, through which any gas, generated within the vessel when placed in the oven or furnace, may be allowed to escape.

The crucibles are now to be ranged round the oven, and placed, one upon another, in vertical positions; and when the oven is properly heated, gas will be generated within each crucible, and issue out from the central hole. The gas thus emitted, being of an inflammable quality, will take fire, and assist in heating the crucibles; and the operation being carried on until the crucibles become of a red heat, the oven is then to be closed, and allowed to cool; after which the crucibles are to be removed, when the charcoal will be found to have become perfectly renovated, and fit for use as before.

BORAX. A native saline compound of boracic acid and soda, found abundantly in Thibet and in South America. The crude product from the former locality was imported into Europe under the name of tincal, and was purified from some adhering fatty matter by a process kept a long time secret by the Venetians and the Dutch, and which consisted chiefly in boiling the substance in water with a little quicklime.

Gmelin found borax, in prismatic crystals, to contain 46·6 per cent. of water; and Arvredson, in the calcined state, to consist of 68·9 of acid and 31·1 soda, in 100 parts. M. Payen describes an octahedral borax, which contains only 30·64 per cent. of water, and is therefore preferred by the brasiers in their soldering processes.

Borax has a sweetish, somewhat lixivial taste, and affects vegetable colors like an alkali; it is soluble in 12 parts of cold and 2 of boiling water. It effloresces and becomes opaque in a dry atmosphere, and appears luminous, by friction, in the dark. It melts at a heat a little above that of boiling water, and gives out its water of crystallization, after which it forms a spongy mass, called calcined borax. The octahedral borax, which is prepared by crystallization, in a solution of 1·256 sp. gr., kept up at 145° F., is not efflorescent. When borax is ignited, it fuses into a glassy-looking substance.

The following is the improved mode of purifying borax. The crude crystals are to be broken into small lumps, and spread upon a filter lined with a lead grating, under which a piece of cloth is stretched upon a wooden frame. The lumps are piled up to the height of 12 inches, and washed with small quantities of a caustic soda ley of 5° B. (sp. gr. 1·033) until the liquor comes off nearly colorless; they are then drained, and put into a large copper of boiling water, in such quantities that the resulting solution stands 20° B. (sp. gr. 1·160.) Carbonate of soda, equivalent to 12 per cent. of the borax, must now be added; the mixed solution is allowed to settle, and the clear liquid syphoned off into crystallizing vessels. Whenever the mother waters get foul, they must be evaporated to dryness in cast-iron pots, and roasted, to burn away the viscid coloring matter.

Borax is sometimes adulterated with alum and common salt; the former addition may be readily detected by a few drops of water of ammonia, which will throw down its alumina; and the latter by nitrate of silver, which will give with it a precipitate insoluble in nitric acid.

The native boracic acid obtained from the lakes of Tuscany, which has been manufactured in France into borax, has greatly lowered the price of this article of commerce. When MM. Payen and Cartier first began the business, they sold the crystals at the same price as the Dutch, viz., 7 francs the kilogramme (2¼ lbs. avoird.); but, in a few

years, they could obtain only 2 francs and 60 centimes, in consequence of the market getting overstocked. The annual consumption of France in 1823 was 25,000 kilos., and the quantity produced in M. Payen's works was 50,000. The mode of making borax from the acid is as follows:—The lake water is evaporated in graduation houses, and then concentrated in boilers till it crystallizes. In that state it is carried to Marseilles. About 500 kilogrammes of water are made to boil in a copper, and 600 kilogrammes of crystallized carbonate of soda are dissolved in it by successive additions of 20 kilogrammes. The solution being maintained at nearly the boiling point, 500 kilogrammes of the crystallized boracic acid of Tuscany are introduced, in successive portions. At each addition of about 10 kilogrammes, a lively effervescence ensues, on which account the copper should be of much greater capacity than is sufficient to contain the liquors. When the whole acid has been added, the fire must be damped by being covered up with moist ashes, and the copper must be covered with a tight lid and blankets, to preserve the temperature uniform. The whole is left in this state during 30 hours; the clear liquor is then drawn off into shallow crystallizing vessels of lead, in which it should stand no higher than 10 or 12 inches, to favor its rapid cooling. At the end of three days in winter, and four in summer, the crystallization is usually finished. The mother water is drawn off, and employed, instead of simple water, for the purpose of dissolving fresh crystals of soda. The above crystals are carefully detached with chisels, redissolved in boiling water, adding for each 100 kilos., 10 kilos. of carbonate of soda. This solution marks 20° B. (sp. gr. 1·160); and, at least, one ton (1000 kilos.) of borax should be dissolved at once, in order to obtain crystals of a marketable size. Whenever this solution has become boiling hot, it must be run off into large crystallizing lead chests of the form of inverted truncated pyramids, furnished with lids, enclosed in wooden frames, and surrounded with mats to confine the heat. For a continuous business, there should be at least 18 vessels of this kind; as the solution takes a long time to complete its crystallization, by cooling to 30° C. (86° F.) The borax crystals are taken out with chisels, after the liquor has been drawn off, and the whole has become cold.

One hundred parts of the purest acid, usually extracted from the lakes of Tuscany, contain only fifty parts of the real boracic acid, and yield no more, at the utmost, than 140 or 150 of good borax.

Dry borax acts on the metallic oxydes at a high temperature, in a very remarkable manner, melting and vitrifying them into beautiful colored glasses. On this account, it is a most useful reagent for the blowpipe. Oxyde of chrome tinges it of an emerald green; oxyde of cobalt, an intense blue; oxyde of copper, a pale green; oxyde of tin, opal; oxyde of iron, bottle-green and yellow; oxyde of manganese, violet; oxyde of nickel, pale emerald green. The white oxydes impart no color to it by themselves. In the fusion of metals, borax protects their surface from oxydizement, and even dissolves away any oxydes formed upon them; by which twofold agency it becomes an excellent flux, invaluable to the goldsmith in soldering the precious metals, and to the brasier in soldering copper and iron.

Borax absorbs muriatic and sulphurous acid gases, but no others, whereby it becomes, in this respect, a useful means of analysis.

The strength or purity of borax may be tested by the quantity of sulphuric acid requisite to neutralize a given weight of it, as indicated by tincture of litmus.

When mixed with shell-lac in the proportion of one part to five, borax renders that resinous body soluble in water, and forms with it a species of varnish.

Boracic acid is a compound of 31·19 of boron, and 68·81 oxygen, in 100 parts. Its prime equivalent referred to oxygen 100, is 871·96.

The following process for refining the native Indian borax or tincal, has been published by MM. Robiquet and Marchand :—   •

It is put into large tubs, covered with water for 3 or 4 inches above its surface, and stirred through it several times during six hours. For 400 pounds of this tincal, there must now be added one pound of quicklime diffused through two quarts of water. Next day the whole is thrown upon a sieve, to drain off the water with the impurities, consisting, in some measure, of the fatty matter combined with the lime, as an insoluble soap. The borax, so far purified, is to be dissolved in 2½ times its weight of boiling water, and eight pounds of muriate of lime are to be added for the above quantity of borax. The liquor is now filtered, evaporated to the density of 18° or 20° B. (1·14 to 1·16 sp. grav.), and set to crystallize in vessels shaped like inverted pyramids, and lined with lead. At the end of a few days, the crystallization being completed, the mother waters are drawn off, the crystals are detached and dried. The loss of weight in this operation is about 20 per cent.

The quantity of borax imported into the United Kingdom in 1835 was 335,224 pounds; whereof 122,022 pounds were exported. The duty is 10s. upon the refined, and 4s. unrefined.

BOOKBINDING is the art of sewing together the sheets of a book, and securing them with a back and side boards. Binding is distinguished from stitching, which is merely sewing the leaves without bands or backs; and from half-binding, which consists in securing the back only with leather, the pasteboard sides being covered with blue or marble paper; whereas in binding, both the back and sides are covered with leather.

Bookbinding, according to the present mode, is performed in the following manner: —The sheets are first folded into a certain number of leaves, according to the form in which the book is to appear; viz., two leaves for folios, four for quartos, eight for octavos, twelve for duodecimos, &c. This is done with a slip of ivory or boxwood, called a folding-stick; and in the arrangement of the sheets the workmen are directed by the catch-words and signatures at the bottom of the pages. When the leaves are thus folded and arranged in proper order, they are usually beaten upon a stone with a heavy hammer, to make them solid and smooth, and are then condensed in a press. After this preparation they are sewed in a sewing press, upon cords or packthreads called bands, which are kept at a proper distance from each other, by drawing a thread through the middle of each sheet, and turning it round each band, beginning with the first and proceeding to the last. The number of bands is generally six for folios, and five for quartos, or any smaller size. The backs are now glued, and the ends of the bands are opened, and scraped with a knife, that they may be more conveniently fixed to the pasteboard sides; after which the back is turned with a hammer, the book being fixed in a press between boards, called backing boards, in order to make a groove for admitting the pasteboard sides. When these sides are applied, holes are made in them for drawing the bands through, the superfluous ends are cut off, and the parts are hammered smooth. The book is next pressed for cutting; which is done by a particular machine called the plough, to which is attached a knife. See the figures and descriptions infra. It is then put into a press called the cutting press, betwixt two boards, one of which lies even with the press, for the knife to run upon; and the other above for the knife to cut against. After this the pasteboards are cut square with a pair of iron shears; and last of all, the colors are sprinkled on the edges of the leaves, with a brush made of hog's bristles; the brush being held in the one hand, and the hair moved with the other.

Different kinds of binding are distinguished by different names, such as law binding, marble binding, French binding, Dutch binding, &c. In Dutch binding, the backs are vellum. In French binding a slip of parchment is applied over the back between each band, and the ends are pasted upon the inside of each pasteboard. This indorsing, as it is called, is peculiar to the French binders; who are enjoined, by special ordonnance, to back their books with parchment. The parchment is applied in the press, after the back has been grated to make the paste take hold. The Italians still bind in a coarse thick paper, and this they call binding alla rustica. It is extremely inconvenient, as it is liable to wear without particular care.

A patent was obtained in 1799 by Messrs. John and Joseph Williams, stationers in London, for an improved method of binding books of every description. The improvement consists of a back, in any curved form, turned a little at the edges, and made of iron, steel, copper, brass, tin, or of ivory, bone, wood, vellum, or, in short, any material of sufficient firmness. This back is put on the book before it is bound, so as just to cover without pressing the edges, and the advantage of it is that it prevents the book, when opened, from spreading on either side, and causes it to rise in any part to nearly a level surface. In this method of binding the sheets are prepared in the usual manner, then sewed on vellum slips, glued, cut, clothed, and boarded, or half boarded; the first back is then fastened to the sides by vellum drawn through holes, or secured by enclosing it in vellum or ferret wrappers, or other materials pasted down upon the boards, or drawn through them.
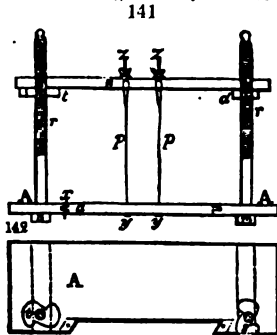
A patent was likewise obtained in 1800 by Mr. Ebenezer Palmer, a London stationer, for an improved way of binding books, particularly merchants' account-books. This improvement has been described as follows:—let several small bars of metal be provided, about the thickness of a shilling or more, according to the size and thickness of the book: the length of each bar being from half an inch to several inches, in proportion to the strength required in the back of the book. At each end of every bar let a pivot be made of different lengths, to correspond to the thickness of two links which they are to receive. Each link must be made in an oval form, and contain two holes proportioned to the size of the pivots, these links to be the same metal as the hinge, and each of them nearly equal in length to the width of two bars. The links are then to be riveted on the pivots, each pivot receiving two of them, and thus holding the hinge together, on the principle of a link-chain or hinge. There must be two holes or more of different sizes, as may be required, on each bar of the hinge or chain; by means of these holes each section of the book is strongly fastened to the hinge which operates with the back

of the book, when bound, in such a manner as to make the different sections parallel
with each other, and thus admit writing without inconvenience on the ruled lines, close
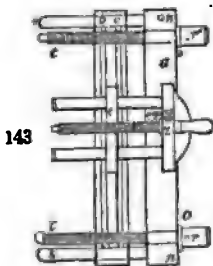to the back.

The leather used in covering books is prepared and applied as follows: being first
moistened in water, it is cut to the size of the book, and the thickness of the edge is
paired off on a marble stone. It is next smeared over with paste made of wheat flour,
stretched over the pasteboard on the outside, and doubled over the edges within. The
book is then corded, that is, bound firmly betwixt two boards, to make the cover stick
strongly to the pasteboard and the back; on the exact performance of which the neat-
ness of the book in a great measure depends. The back is then warmed at the fire to
soften the glue, and the leather is rubbed down with a bodkin or folding stick, to set and
fix it close to the back of the book. It is now set to dry, and when dry, the boards are
removed; the book is then washed or sprinkled over with a little paste and water, the
edges and squares blacked with ink, and then sprinkled fine with a brush, by striking it
against the hand or a stick; or with large spots, by being mixed with solution of green
vitriol, which is called marbling. Two blank leaves are then pasted down to the cover,
and the leaves, when dry, are burnished in the press, and the cover rolled on the edges.
The cover is now glazed twice with the white of an egg, filleted, and, last of all, polished,
by passing a hot iron over the glazed color.

The employment in bookbinding of a rolling press for smoothing and condensing the
leaves, instead of the hammering which books have usually received, is an improvement
introduced several years ago into the trade by Mr. W. Burn. His press consists of two
iron cylinders about a foot in diameter, adjustable in the usual way, by means of a screw,
and put in motion by the power of one man or of two, if need be, applied to one or two
winch-handles. In front of the press sits a boy who gathers the sheets into packets, by
placing two, three, or four, upon a piece of tin plate of the same size, and covering them
with another piece of tin plate, and thus proceeding by alternating tin plates and bundles
of sheets till a sufficient quantity have been put together, which will depend on the stiff-
ness and thickness of the paper. The packet is then passed between the rollers and re-
ceived by the man who turns the winch, and who has time to lay the sheets on one side,
and to hand over the tin plates by the time that the boy has prepared a second packet.
A minion Bible may be passed through the press in one minute, whereas the time
necessary to beat it would be twenty minutes. It is not, however, merely a saving of
time that is gained by the use of the rolling-press; the paper is made smoother than it

would have been by beating, and the compression is
so much greater, that a rolled book will be reduced
to about five sixths of the thickness of the same book
if beaten. A shelf, therefore, that will hold fifty
books bound in the usual way would hold nearly
sixty of those bound in this manner, a circumstance
of no small importance, when it is considered how
large a space even a moderate library occupies, and
that book cases are an expensive article of furniture.
The rolling press is now substituted for the hammer
by several considerable bookbinders.

Fig. 141 represents the sewing-press, as it stands
upon the table, before which the bookbinder sits.
Fig. 142 is a ground plan, without the parts *a* and
n in the former figure. A is the base-board, sup-
ported upon the cross bars *m n*, marked with dotted
lines in *fig.* 142. Upon the screw rods *r r*, *fig.* 141, the nuts *t d* serve to fix the flat upper
bar *n*, at any desired distance from the base. That bar has a slit along its middle, through
which the hooks below *ε z* pass down for receiving the ends of the sewing cords *p p*,
fixed at *y y*, and stretched by the thumb-screws *z z*.
The bar *y y* is let into an oblong space cut out of the
front edge of the base-board, and fixed there by a
moveable pin *a*, and a fixed pin at its other end, round
which it turns.

Fig. 143 is the bookbinder's cutting-press, which is
set upright upon a sort of chest for the reception of
the paper parings; and consists of three sides, being
open above and to the left hand of the workman.
The pressbar, or beam *a*, has two holes *n n* upon its
under surface, for securing it to two pegs standing on
the top of the chest. The screw rods *t t* pass through
two tapped holes in the bar, marked with *b c* at its

upper end; their heads *r r* being held by the shoulders *o o*. The heads are pierced with

noles into which lever pins are thrust for screwing the rods hard up. The heavy beam *a* remains immoveable, while the parallel bar with the book is brought home towards it by the two screws. The two rulers *s s* serve as guides to preserve the motions truly parallel; and the two parallel lath bars *b c* guide between them the end bar *e*, of the plough, whose knife is shown at *i*, with its clamping screw *z*.

Mr. Oldham, printing engineer of the Bank of England, distinguished for mechanical ingenuity, has contrived a convenient machine for cutting the edges of books, banknotes, &c., either truly square or polygonal, with mathematical precision. *Fig.* 144, represents an end elevation of the machine. *Fig.* 145, a side view of the same, the letters of reference indicating the same parts of the machine in each of the figures.

a, is the top cross bar with rectangular grooves *b b*; *c c*, are side posts; *d d*, cross feet to the same, with strengthening brackets; *e e*, a square box, in which the press stands, for holding waste cuttings. *Fig.* 146, is a cross section of the upright posts, *c c*, taken horizontally. There are rectangular grooves in the upright posts, for the projecting ends of the cast iron cross bracket *f*, to slide up and down in. In the middle of the under-side of this piece *f*, there is a boss, within which is a round recess, to receive the top of the screw *g*, which works in the cast iron cross piece *h*, similarly made with the former, but bolted firmly to the posts *c c*. Upon the screw *g*, there is a circular handle or ring *i*, for
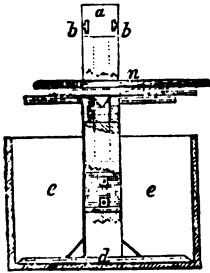
144   145
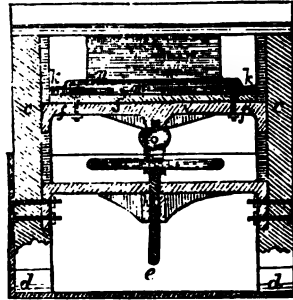
partially turning the screw, and immediately over it cross holes for tightening the press by means of a lever bar. Upon the cross piece *f*, is bolted the board *j*, and upon each end of this board is made fast the rabbeted pieces *k k*, for another board *l*, to slide in.
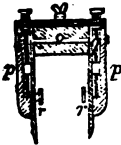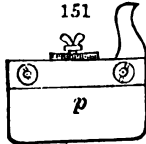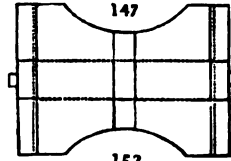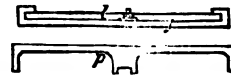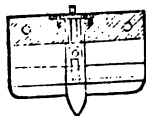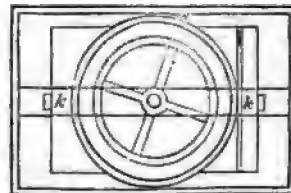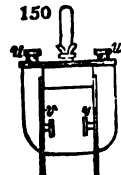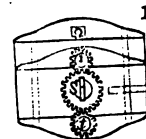
Across the middle of this board, and parallel to the pieces *k k*, the tongue piece *m* is made fast, which fits into a groove in the bottom of board *l*. A horizontal representation of this is seen at *fig.* 147, and immediately under this view is also seen an end view of *l* and *f*, connected together, and a side view of *f* by itself. In the middle of the board *l*,

is a pin for a circular board *n*, to turn upon, and upon this letter board is placed the " material to be cut," with a saving piece between it, and the circular piece which is to be divided upon its edge into any number of parts required, with a stationary index on the board *l*, to point to each.

It will now be understood that the " material to be cut," may be turned round upon the centre pin of the board *n*, and also that both it and the board can be shifted backward and forward under the top cross piece *a*, and between the side slide slips *k k*, the surfaces of which should also be divided into inches and tenths.

The plough, *fig.* 148, shown in several positions, is made to receive two knives or cutters as the "material to be cut" may require, and which are situated in the plough as I now describe. The plough is composed of three principal parts, namely, the top, and its two sides. The top *o*, is made the breadth of the cross piece *a*, and with a handle made fast thereon. The sides *p p*, are bolted thereto, with bolts and nuts through corresponding holes in the top and sides. The figures below give inside views, and cross sections of the details of the manner in which the cutters and adjustments are mounted. A groove is cut down each cheek or side, in which are placed screws that are held at top and bottom from moving up and down, but by turning they cause the nuts upon them to do so; they are shown at *q q*. These nuts have each a pin projecting inwards, that go into plain holes made in the top ends of cutters *r r*. The 148th and following figs. are ½ in scale.

The cutters, and the work for causing them to go up and down, are sunk into the cheeks, so as to be quite level with their inner surfaces. *Fig.* 149 shows one of those screws apart, how fixed, and with moveable nut and projecting pin. The top of each screw terminates with a round split down, and above it a pinion wheel and boss thereon, also similarly split. This pinion fits upon the split pin. Above, there is a cross section of a hollow coupling cap with steel tongue across, that fits into both the cuts of the screw pin and pinion boss, so that when lowered upon each other, they must all turn together. In the middle and on the top of the upper piece *o*, the larger wheel *s*, runs loose upon its centre, and works into the two pinion-wheels *t t*. The wheel *s* has a fly-nut with wings mounted upon it.

It will now be seen, when the plough is in its place as at *fig.* 150, that if it be pushed to and fro by the right hand, and the nut occasionally turned by the left, the knives or cutters will be protruded downwards at the same time, and these either will or will not advance as the coupling caps *u u* are on or off. The ribs *v v*, run in the grooves *b b*, *fig.* 144, and keep the cutters to their duty, working steadily. The top cross bar *a*, is the exact breadth of a bank-note, by which means both knives are made to cut at the same time. The paper is cut uniformly to one length, and accurately square.

By the use of this machine, the air-pump paper-wetting apparatus, and appendant press, the paper of 45,000 notes is fully prepared in one hour and a half by one person, and may then be printed. It is not so much injured by this process as by the ordinary method of clipping by hand, soaking it, &c., which more or less opens and weakens the fabric, especially of bank-note paper.

One of the greatest improvements ever made in the art of bookbinding is, apparently, that for which Mr. William Hancock has very recently obtained a patent. After folding the sheets in double leaves, he places them vertically, with the edges forming the back of the book downwards in a concave mould, of such rounded or semi-cylindrical shape as the back of the book is intended to have. The mould for this purpose consists of two parallel upright boards, set apart upon a cradle frame, each having a portion or portions cut out vertically, somewhat deeper than the breadth of the book, but of a width nearly equal to its thickness before it is pressed. One of these upright boards may be slidden nearer to or farther from its fellow, by means of a guide bar, attached to the sole of the cradle. Thus the distance between the concave bed of the two vertical slots in which the book rests, may be varied according to the length of the leaves. In all cases about one fourth of the length of the book at each end projects beyond the board, so that one half rests between the two boards. Two or three packthreads are now bound round the leaves thus arranged, from top to bottom of the page in different lines, in order to preserve the form given to the back of the mould in which it lay. The book is next subjected to the action of the press. The back, which is left projecting *very slightly* in front, is then smeared carefully by the fingers with a solution of caoutchouc, whereby each paper-edge receives a small portion of the cement. In a few hours it is sufficiently dry to take another coat of a somewhat stronger caoutchouc solution. In 48 hours, 4 applications of the caoutchouc may be made and dried. The back and the adjoining part of the sides are next covered with the usual band or fillet of cloth, glued on with caoutchouc; after which the book is ready to have the boards attached, and to be covered with leather or parchment as may be desired.

We thus see that Mr. Hancock dispenses entirely with the operations of stitching, sewing, sawing-in, hammering the back, or the use of paste and glue. Instead of leaves

attached by thread stitches at 2 or 3 points, we have them agglutinated securely along their whole length. Books bound in this way open so perfectly flat upon a table without strain or resilience, that they are equally comfortable to the student, the musician, and the merchant. The caoutchouc cement moreover, being repulsive to insects, and not affected by humidity, gives this mode of binding a great superiority over the old method with paste or glue, which attracted the ravages of the moth, and in damp situations allowed the book to fall to pieces. For engravings, atlases, and legers, this binding is admirably adapted, because it allows the pages to be displayed most freely, without the risk of dislocating the volume; but for security, 3 or 4 stitches should be made. The leaves of music-books bound with caoutchouc, when turned over, lie flat at their whole extent, as if in loose sheets, and do not torment the musician like the leaves of the ordinary books, which are so ready to spring back again. Manuscripts and collections of letters which happen to have little or no margin left at the back for stitching them by, may be bound by Mr. Hancock's plan without the least encroachment upon the writing. The thickest legers, thus bound, open as easily as paper in quire, and may be written on up to the innermost margin of the book without the least inconvenience.

Having inspected various specimens of Mr. Hancock's workmanship, I willingly bear testimony to the truth of the preceding statement. See CLOTH BINDING.
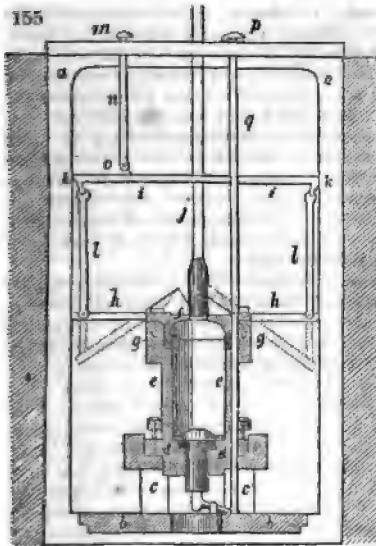
BOTTLE MANUFACTURE. The following mechanism for moulding bottles forms the subject of a patent obtained by Henry Rickets of Bristol, in 1822. *Fig.* 155 is a section of the apparatus, consisting of a square frame, *a a*, of iron or wood; this is fixed in a pit formed in the floor; *b b* is the base of the frame, with an aperture for knocking up the bottom of the bottle; *c c* are four legs secured to the frame-floor *b*, upon which the mould is supported. The platform or stand of the mould *d d* has an opening in its centre for the introduction of the bottom of the mould, which is raised against the bottom of the bottle by the knocker-up; *e e* are the sides of the mould; and *f f* is the top of the mould in two pieces, turning over upon the joints at *g g*, so as to form the neck of the bottle; *h h* are levers or arms for raising and depressing the top pieces; *i i* is a horizontal shaft or axle, turning in bearings at each end, from which shaft two levers, *k k*, extend; these levers are connected by upright rods, *l l*, to the levers or arms, *h h*, of the top pieces *f f*.

The weight of the arms *h h*, and rods *l l*, will, by their gravity, cause the top pieces to open, as shown by the dotted lines; in this situation of the mould, the melted glass is to be introduced by a tube as usual. The workman then steps with one foot upon the knob *m*, which forces down the rod *n*, and by means of a short lever *o*, extending from the shaft *i*, forces down the top pieces *f*, and closes the mould, as seen in the figure; the glass is then made to extend itself to the shape of the mould, by blowing as usual, so as to form the bottle, and the workman at this time putting his other foot upon the knob *p*, depresses the rod *q*, and hence raises the bottom of the mould by means of the knocker-up, *r*, so as to form the bottom of the bottle.

At the bottom of the mould a ring is introduced of any required thickness, for the purpose of regulating the capacity of the bottle; upon which ring it is proposed to raise letters and figures, as a mould to imprint the maker's name and the size of the bottle. These moulds can be removed and changed at pleasure. Under the knob *p*, a collar or washer is to be introduced, of any required thickness, to regulate the knocking up of the bottom, by which a perfect symmetry of form is presented. In order to make bottles of different sizes or forms, the mould is intended to be removed, and its place supplied by another mould of different dimensions and figure; the lower parts of all the moulds being made to fit the same frame. Such a mould ought to be prescribed by legislative enactment, with an excise stamp to define the capacity of every bottle, and thereby put an end to the interminable frauds committed in the measure of wine and all other liquors sold by the bottle.

BOUGIE. A smooth, flexible, elastic, slender cylinder, introduced into the urethra, rectum, or œsophagus, for opening or dilating it, in cases of stricture and other diseases.

The invention of this instrument is claimed by Alderete. a Portuguese physician, but its form and uses were first described by his pupil Amatus, in the year 1554. Some are solid, and some hollow; some corrosive, and some mollifying. They generally owe their elasticity to linseed oil, inspissated by long boiling, and rendered drying by litharge. This viscid matter is spread upon a very fine cord or tubular web of cotton, flax, or silk, which is rolled upon a slab when it becomes nearly solid by drying, and is finally polished in the same way.

Pickel, a French professor of medicine, published the following recipe for the composition of bougies. Take 3 parts of boiled linseed oil, one part of amber, and one of oil of turpentine; melt and mix these ingredients well together, and spread the compound at three successive intervals upon a silk cord or web. Place the pieces so coated in a stove heated to 150° F.; leave them in it for 12 hours, adding 15 or 16 fresh layers in succession, till the instruments have acquired the proper size. Polish them first with pumice-stone, and finally smooth with tripoli and oil. This process is the one still employed in Paris, with some slight modifications; the chief of which is dissolving in the oil one twentieth of its weight of caoutchouc to render the substance more solid. For this purpose the caoutchouc must be cut into slender shreds, and added gradually to the hot oil. The silk tissue must be fine and open, to admit of the composition entering freely among its filaments. Each successive layer ought to be dried first in a stove, and then in the open air, before another is applied. This process takes two months for its completion, in forming the best bougies called elastic; which ought to bear twisting round the finger without cracking or scaling, and extension without giving way, but retracting when let go. When the bougies are to be hollow, a mandril of iron wire, properly bent with a ring at one end, is introduced into the axis of the silk tissue. Some bougies are made with a hollow axis of tin foil rolled into a slender tube. Bougies are also made entirely of caoutchouc, by the intervention of a solution of this substance in sulphuric ether, a menstruum sufficiently cheap in France, on account of the low duty upon alcohol. There are medicated bougies, the composition of which belongs to surgical pharmacy. The manufacture of these instruments of various kinds forms a separate and no inconsiderable branch of industry at Paris. MM. Feburger and Lamotte are eminent in this line.

BRACES. (*Bretelles*, Fr.; *Hosenträger*, Germ.) Narrow fillets or bands of leather or textile fabric, which pass over the shoulders, and are attached behind and before to the waistbands of pantaloons and trousers, in the act of wearing them, for supporting their weight, and *bracing* them up to the body. It is a useful modern invention, superseding the necessity of girding the belly with a tight girdle, as in former times.

BRAIDING MACHINE. (*Machine à lacets*, Fr.; *Bortenwerkerstuhl*, Germ.) This being employed not only to manufacture stay-laces, braid, and upholsterers' cord, but to cover the threads of caoutchouc for weaving brace-bands, deserves a description in this work. Three threads at least are required to make such a knitted lace, but 11, 13, or 17, and even 29 threads are often employed, the first three numbers being preferred. They are made by means of a frame of a very ingenious construction, which moves by a continuous rotation. We shall describe a frame with 13 threads, from which the structure of the others may be readily conceived. The basis of the machine consists of
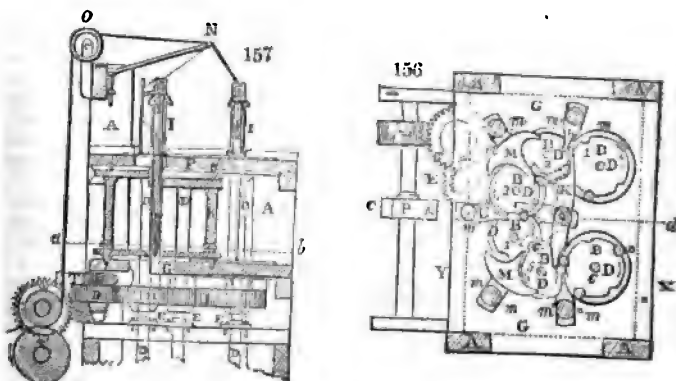
four strong wooden uprights, A, *figs.* 156, 157, 158, occupying the four angles of a rectangle, of which one side is 14 inches long, the other 18 inches, and the height of the rectangle about 40 inches. *Fig.* 156 is a section in a horizontal plane, passing through the line *a b* of *fig.* 157, which is a vertical section in a plane passing through the centre of

the machine c, according to the line c d, fig. 156. The side x is supposed to be the front of the frame; and the opposite side, y, the back. B, six spindles or skewers, numbered, from 1 to 6, placed in a vertical position upon the circumference of a circle, whose centre coincides with that of the machine at the point c. These six spindles are composed, 1. Of so many iron shafts or axes p, supported in brass collets E (fig. 157), and extended downwards within six inches of the ground, where they rest in brass steps fixed upon a horizontal beam. 2. Wooden heads, made of horn-beam or nut-tree, placed, the first upon the upper end of each spindle, opposite the cut-out beam F, and the second opposite the second beam G. 3. Wooden-toothed wheels, H, reciprocally working together, placed between the beam G and the collet-beam E. The toothed wheels and the lower heads for each spindle are in one piece.

The heads and shafts of the spindles No. 1 and 6, are one fifth stronger than those of the other spindles; their heads have five semicircular grooves, and wheels of 60 teeth, while the heads of the others have only four grooves, and wheels of 48 teeth; so that the number of the grooves in the six spindles is 26, one half of which is occupied with the stems of the puppets I, which carry the 13 threads from No. 1 to 13. The toothed wheels, which give all the spindles a simultaneous movement, but in different directions, are so disposed as to bring their grooves opposite to each other in the course of rotation.

I, the middle winglet, triple at bottom and quintuple at top, which serves to guide the puppets in the direction they ought to pursue.

L, three winglets, single at top and bottom, placed exteriorly, which serve a like purpose.

M, two winglets, triple at bottom and single at top, placed likewise exteriorly, and which serve the same purposes as the preceding; m are iron pins inserted in the cut-out beam c, which serve as stops or limits to the oscillations of the exterior winglets.

Now, if by any moving power (a man can drive a pair) rotation be impressed upon the large spindle No. 1, in the direction of the arrow, all the other spindles will necessarily pursue the rotatory movement indicated by the respective arrows. In this case, the 13 puppets working in the grooves of the heads of the spindles will be carried round simultaneously, and will proceed each in its turn, from one extremity of the machine to the opposite point, crossing those which have a retrograde movement. The 13 threads united at the point N, situated above the centre of the machine, will form at that point the braid, which, after having passed over the pulley o, comes between the two rollers P Q, and is squeezed together, as in a flatting-mill, where the braid is calendered at the same time that it is delivered. It is obvious that the roller P receives its motion from the toothed wheel of the spindle No. 3, and from the intermediate wheels R, s, T, as well as from the endless screw z, which drives at proper speed the wheel w, fixed upon the shaft of the roller P.

The braid is denser in proportion as the point N is less elevated above the tops of the puppets; but in this case, the eccentric motion of these puppets is much more sensible in reference to that point towards which all the threads converge than when it is elevated. The threads, which must be always kept equally stretched by means of a weight, as we shall presently see, are considerably strained by the traction, occasioned by the constantly eccentric movement of the puppets. From this cause, braiding machines must be worked at a moderate velocity. In general, for fine work, 30 turns of the large spindle per minute are the utmost that can safely be made.

The puppet or spindle of this machine, being the most important piece, I have represented it in section, upon a scale one fourth of its actual size, fig. 158. It is formed of a tube, a, of strong sheet iron well brazed; b is a disc, likewise of sheet iron, from which a narrow fillet, c, rises vertically as high as the tube, where both are pierced with holes, d e, through which the thread f is passed, as it comes from the bobbin, g, which turns freely upon the tube a. The top of this bobbin is conical and toothed. A small catch or detent, h, moveable in a vertical direction round i, falls by its own weight into the teeth of the crown of the bobbin, in which case this cannot revolve; but when the detent is raised so far as to disengage the teeth, and at the same time to pull the thread, the bobbin turns, and lets out thread till the detent falls back into these same teeth.

A skewer of iron wire, k, is loaded with a small weight, l, melted upon k. The top of this skewer has an eye in it, and the bottom is recurved as is shown in fig. 156, so that supposing the thread comes to break, this skewer falls into the actual
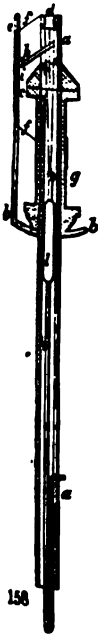
position in the figure, where we see its lower end extending beyond the tube a, by about $\frac{1}{4}$ of an inch; but as long as the thread is unbroken, the skewer k, which serves to keep it always tense, during the eccentric movement of the puppet, does not pass out below the tube.

This disposition has naturally furnished the means of causing the machine to stop, whenever one of the threads breaks. This inferior protrusion of the skewer pushes in its progress a detent, which instantly causes the band to slide from the driving pulley to the loose pulley. Thus the machine cannot operate unless all the threads be entire. It is the business of the operative, who has 3 or 4 under her charge, to mend the threads as they break, and to substitute full bobbins for empty ones, whenever the machine is stopped.

The brailing frame, though it does not move quickly, makes a great deal of noise, and would make still more, were the toothed wheels made of metal instead of wood. For them to act well, they should be made with the greatest precision, by means of appropriate tools for forming the teeth of the wheels, and the other peculiar parts.

BRAN. (*Son*, Fr.; *Kleie*, Germ.) The husky portion of ground wheat, separated by the bolter from the flour. It is advantageously employed by the calico printers, in the clearing process, in which, by boiling in bran-water, the coloring matters adhering to the non-mordanted parts of maddered goods, as well as the dun matters which cloud the mordanted portions, are removed. A valuable series of researches concerning the operation of bran in such cases was made a few years ago by that distinguished chemist and calico printer, M. Daniel Kœchlin Schouch, and published in the ninth number of the Bulletin de la Société Industrielle de Mulhausen. Nine sets of experiments are recorded, which justified the following conclusions.

1. The dose of two bushels of bran for 10 pieces of calico is the best, the ebullition being kept up for an hour. A boil for the same time in pure water had no effect in clearing either the grounds or the figures.

2. Fifteen minutes boiling are sufficient when the principal object is to clear white grounds, but in certain cases thirty minutes are requisite to brighten the dyed parts. If, by increasing the charge of bran, the time of the ebullition could be shortened, it would be in some places, as Alsace, an economy; because for the passage of ten pieces through a copper or vat heated with steam, 1 cwt. of coal is consumed in fuel which costs from $2\frac{1}{2}$ to 3 francs, while two bushels of bran are to be bought for one franc.

3. By increasing the quantity of water from 12 to 24 hectolitres with two bushels of bran, the clearing effect upon the ten pieces was impaired. It is therefore advantageous not to use too much water.

4. Many experiments concur to prove that flour is altogether useless for the clearing boil, and that finer bran is inferior for this purpose to the coarser.

5. The white ground of the calicoes boiled with wheat bran, are distinguishable by their superior brightness from that of those boiled with rye bran, and especially with barley bran; the latter having hardly any effect.

6. There is no advantage in adding soap to the bran boil; though a little potash or soda may be properly introduced when the water is calcareous.

7. The pellicle of the bran is the most powerful part, the flour and the starch are of no use in clearing goods, but the mucilage which forms one third of the weight of the bran has considerable efficacy, and seems to act in the following way. In proportion as the mucilaginous substance dissolves the coloring and tawny matters upon the cloth, the husky surface attracts and fixes upon itself the greater part of them. Accordingly, when used bran is digested in a weak alkaline bath, it gives up the color which it had absorbed from the cloth.

The following chemical examination of bran is interesting. A pound of it was boiled at successive times with water; the decoctions, being filtered, let fall in cooling a grayish deposite, which was separated by decantation. The clear liquor afforded by evaporation to dryness four ounces of a brownish, brittle matter, composed chiefly of mucilage, a little gluten, and starch. The gray deposite of the above filtered liquor amounted to half an ounce. Nine ounces of the cortical portion of the bran were obtained. The loss amounted to $2\frac{1}{2}$ ounces, being in some measure the hygrometric water of the bran itself.

When boiled with distilled water, goods are cleared pretty well without bran. Certain delicate dyes must be boiled only a few minutes in a strong decoction of bran previously made.

BRANDY. The name given in this country to ardent spirits distilled from wine, and possessed of a peculiar taste and flavor, due to a minute portion of a peculiar volatile oil. Each variety of alcohol has an aroma characteristic of the fermented substance from which it is procured; whether it be the grape, cherries, sugar-cane, rice, corn, or potatoes; and it may be distinguished even as procured from different growths of the vine. The brandies of Languedoc, Bordeaux, Armagnac, Cognac, Aunis,

Saintonze, Rochelle, Orleans, Barcelona, Naples, &c. being each readily recognisable by an experienced dealer.

Aubergier showed, by experiments, that the disagreeable taste of the spirits distilled from the *marc* of the grape is owing to an essential oil, contained in the skin of the grape; and found that the oil, when insulated, is so energetic that a few drops are sufficient to taint a pipe of 600 litres of fine flavored spirit.

The most celebrated of the French brandies, those of Cognac and Armagnac, are slightly rectified to only from 0·935 to 0·922; they contain more than half their weight of water, and come over therefore highly charged with the fragrant essential oil of the husk of the grape. When, to save expense of carriage, the spirit is rectified to a much higher degree, the dealer, on receiving it at Paris, reduces it to the market proof by the addition of a little highly-flavored weak brandy and water; but he cannot in this way produce so finely-flavored a spirit, as the weaker product of distillation of the Cognac wine. If the best Cognac brandy be carefully distilled at a low heat, and the strong spirit be diluted with water, it will be found to have suffered much in its flavor.

Genuine French brandy evinces an acid reaction with litmus paper, owing to a minute portion of vinegar; it contains, besides, some acetic ether, and, when long kept in oak casks, a little astringent matter. The following formula may be proposed for converting a silent or flavorless corn spirit, into a factitious brandy. Dilute the pure alcohol to the proof pitch, add to every hundred pounds weight of it from half a pound to a pound of argol (crude winestone) dissolved in water, a little acetic ether, and French wine-vinegar, some bruised French plums, and flavor-stuff from Cognac; then distil the mixture with a gentle fire, in an alembic furnished with an agitator.

The spirit which comes over may be colored with nicely burned sugar (caramel) to the desired tint, and roughened in taste with a few drops of tincture of catechu or oak-bark.

The above recipe will afford a spirit free from the deleterious drugs too often used to disguise and increase the intoxicating power of British brandies; one which may be reckoned as wholesome as alcohol, in any shape, can ever be.

BRASS. (*Laiton, cuivre jaune,* Fr.; *Messing,* Germ.) An alloy of copper and zinc. It was formerly manufactured by cementing granulated copper, called *bean-shot,* or copper clippings, with calcined calamine (native carbonate of zinc) and charcoal, in a crucible, and exposing them to bright ignition. Three parts of copper were used for three of calamine and two of charcoal. The zinc reduced to the metallic state by the agency of the charcoal, combined with the copper, into an alloy which formed, on cooling, a lump at the bottom of the crucible. Several of these, being remelted and cast into moulds, constituted ingots of brass for the market. James Emerson obtained a patent, in 1781, for making brass by the direct fusion of its two metallic elements, and it is now usually manufactured in this way.

It appears that the best proportion of the constituents to form fine brass is one prime equivalent of copper$=63\frac{1}{2}+$one of zinc$=32\cdot3$; or very nearly 2 parts of copper to 1 of zinc. The bright gold colored alloy, called Prince's, or Prince Rupert's metal, in this country, consists apparently of two primes of zinc to one of copper, or of nearly equal parts of each. Brass, or hard solder, consists of two parts of brass and one of zinc melted together, to which a little tin is occasionally added; but when the solder must be very strong, as for brass tubes that are to undergo drawing, two thirds of a part of zinc are used for two parts of brass. Mosaic gold, according to the specification of Parker and Hamilton's patent, consists of 100 parts of copper, and from 52 to 55 of zinc; which is no atomic proportion. Bath metal is said to consist of 32 parts of brass and 9 parts of zinc.

The button manufacturers of Birmingham make their *platin* with 8 parts of brass and 5 of zinc; but their cheap buttons with an alloy of copper, tin, zinc, and lead.

Red brass, the Tombak of some, (not of the Chinese, for this is white copper,) consists of more copper and less zinc than go to the composition of brass; being from 2½ to 8 or 10 of the former to 1 of the latter. At the famous brass works of Hegermühl, to be presently described, 11 parts of copper are alloyed with 2 of zinc into a red brass, from which plates are made that are afterwards rolled into sheets. From such an alloy the Dutch foil, as it is called, is manufactured at Nürnberg; Pinchbeck, Similor, Mannheim gold, are merely different names of alloy similar to Prince's metal. The last consists of 3 of copper and 1 of zinc, separately melted, and suddenly incorporated by stirring.—*Wiegleb.*

In the process of alloying two metals of such different fusibilities as copper and zinc, a considerable waste of the latter metal by the combustion, to which it is so prone, might be expected; but, in reality, their mutual affinities seem to prevent the loss, in a great measure, by the speedy absorption of the zinc into the substance of the copper. Indeed, copper plates and rods are often *brassed* externally by exposure, at a high temperature, to the fumes of zinc, and afterwards laminated or drawn. The spurious

gold wire of Lyons is made from such rods. Copper vessels may be superficially convert-
ed into brass by boiling them in dilute muriatic acid containing some wine-stone and zinc
amalgum.

The first step in making brass is to plunge slips of copper into melted zinc till an alloy
of somewhat difficult fusion be formed, to raise the heat, and add the remaining propor-
tion of the copper.

The brass of the first fusion is broken to pieces, and melted with a fresh quantity of
zinc, to obtain the finished brass. Each melting takes about 8 or 9 hours. The metal
is now cast into plates, about 40 inches long by 26 inches broad, and from one third to
one half inch thick. The moulds are, in this case also, slabs of granite mounted in an iron
frame. Granite appears to be preferred to every thing else as a mould, because it pre-
serves the heat long, and by the asperities of its surface, it keeps hold of the clay lute
applied to secure the joinings.

The cast plates are most usually rolled into sheets. For this purpose they are cut
into ribands of various breadths, commonly about 6½ inches. The cylinders of the
brass rolling-press are generally 46 inches long, and 18 inches in diameter. The
ribands are first of all passed cold through the cylinders; but the brass soon becomes
too hard to laminate. It is then annealed in a furnace, and, after cooling, is passed
afresh through a rolling press. After paring off the chipped edges, the sheets are
laminated two at a time: and if they are to be made very thin, even eight plates are
passed through together. The brass in these operations must be annealed 7 or 8 times
before the sheet arrives at the required thinness. These successive heatings are very
expensive; and hence they have led the manufacturers to try various plans of econo-
my. The annealing furnaces are of two forms, according to the size of the sheets
of brass. The smaller are about 12 feet long, with a fire-place at each end, and about
13 inches wide. The arch of the furnace has a cylindrical shape, whose axis is
parallel to its small side. The hearth is horizontal, and is made of bricks set on edge.
In the front of the furnace there is a large door, which is raised by a lever, or chain,
and counterweight, and slides in a frame between two cheeks of cast iron. This furnace
has, in general, no chimney, except a vent slightly raised above the door, to prevent the
workmen being incommoded by the smoke. Sometimes the arch is perforated with a num-
ber of holes. The sheets of brass are placed above each other, but separated by parings,
to allow the hot air to circulate among them, the lowest sheet resting upon two bars of
cast iron placed lengthwise.

The large furnaces are usually 32 feet long, by 6½ feet wide, in the body, and 3 feet
at the hearth. A grate, 13 inches broad, extends along each side of the hearth,
through its whole length, and is divided from it by a small wall, 2 or 3 inches high.
The vault of the furnace has a small curvature, and is pierced with 6 or 8 openings,
which allow the smoke to pass off into a low bell-chimney above. At each end of the
furnace there is a cast-iron door, which slides up and down in an iron frame, and
is poised by a counterweight. On the hearth there is a kind of railway, composed of
two iron bars, on the grooves of which the carriage moves with its loads of sheets of
brass.

These sheets, being often 24 feet long, could not be easily moved in and out of the
furnace; but as brass laminates well in the cold state, they are all introduced and
moved out together. With this view, an iron carriage is framed with four bars, which
rest on four wheels. Upon this carriage, of a length nearly equal to that of the furnace,
the sheets are laid, with brass parings between them. The carriage is then raised by a
crane to a level with the furnace, and entered upon the grooved bars which lie upon the
hearth. That no heat may be lost, two carriages are provided, the one being ready to
put in as the other is taken out; the furnace is meanwhile uniformly kept hot. This
method, however convenient for moving the sheets in and out, wastes a good deal of fuel
in heating the iron carriage.

The principal places in which brass is manufactured on the great scale in England, are
Bristol, Birmingham, and Holywell, in North Wales.

The French writers affirm, that a brass, containing 2 per cent. of lead, works more
freely in the turning lathe, but does not hammer so well as a mere alloy of copper and
zinc.

At the brass manufactory of Hegermühl, upon the Finon canal near Potsdam, the fol-
lowing are the materials of one charge; 41 pounds of old brass, 55 pounds refined cop-
per (gahrkupfer) granulated; and 24 pounds of zinc. This mixture, weighing 120 pounds,
is distributed into four crucibles, and fused in a wind furnace with pitcoal fuel. The
waste varies from 2½ to 4 pounds upon the whole.

Fig. 159 represents the furnace as it was formerly worked there with charcoal; *a*, the
laboratory in which the crucibles were placed. It was walled with fire-bricks. The foun-
dations and the filling-in walls were formed of stone rubbish, as being bad conductors of
heat; sand and ashes may be also used; *b*, cast-iron circular grating plates pierced with

12 holes (see *fig.* 160), over them a sole of loam, *c*, is beat down, and perforated with holes corresponding to those in the iron discs; *d*, the ash-pit; *e*, the *lock*, a draught flue which

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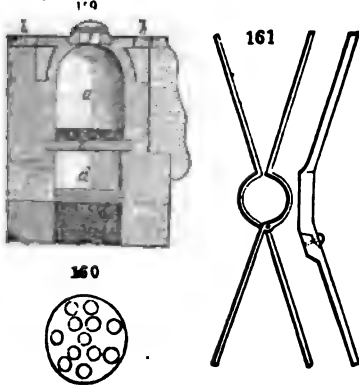
conducts the air requisite to the combustion, from a sunk tunnel, in communication with several melting furnaces. The terrace or crown of the furnace, *f*, lies on a level with the foundry floor, *h, h*, and is shut with a tile of fire-clay, *g*, which may be moved in any direction by means of hooks and eyes in its binding iron ring. *Fig.* 161, the tongs for putting in and taking out the charges, as viewed from above and from the side.

Figs. 162, 163, represent the furnaces constructed more recently for the use of pitcoal fuel; *fig.* 162, being an upright section, and *fig.* 163, the ground plan. In this furnace the crucibles are not surrounded with the fuel, but they receive the requisite melting heat from the flame proceeding from the grate upon which it

is burned. The crucibles stand upon 7 binding arches, *a*, which unite in the middle at the key-stone *b*, *fig.* 165; between the arches are spaces through which the flame rises from the grate *c*; *d* is the fire-door; *e* a

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sliding tile or damper for regulating or shutting off the air-draught; *f* an inclined plane, for carrying off the cinders that fall through the grate, along the draught tunnel *g*, so that the air in entering below may not be heated by them.

The crucibles are 16 inches deep, 9½ wide at the mouth, 6¼ at the bottom; with a thickness in the sides of 1 inch, and 1½ below; they stand from 40 to 50 meltings. The old brass, which fills their whole capacity, is first put in and melted down; the crucibles are now taken out, and are charged with the half of the zinc in pieces of from 1 to 3 cubic inches in size, covered over with coal ashes; then one half of the copper charge is introduced, again coal-dust; and thus the layers of zinc and copper are distributed alternately with coal-ashes betwixt them, till the whole charge gets finally fused. Over all, a thicker layer of carbonaceous matter is laid, to prevent oxidizement of the brass. Eight crucibles f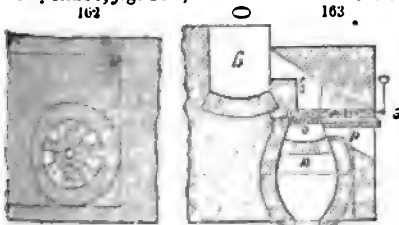illed in this way are put into the furnace between the 11 holes of the grate-shelf; and over them two empty crucibles are laid to be heated for the casting operation. In from 3½ to 4 hours the brass is ready to be poured out. Fifteen English bushels of coals are consumed in one operation; of which six are used at the introduction of the crucibles, and four gradually afterwards.

When sheet brass is to be made the following process is pursued :—

An empty crucible, called a *caster* (*giesser*), is taken out of the furnace through the crown with a pair of tongs, and is kept red hot by placing it in a hollow hearth (*mundal*), surrounded with burning coals; into this crucible the contents of four of the melting pots are poured; the dross being raked out with an iron scraper. As soon as the melting pot is emptied, it is immediately re-charged in the manner above described, and replaced in the furnace. The surface of the melted brass in the *caster* is swept with the stump of a broom, then stirred about with the iron rake, to bring up any light foreign matter to the surface, which is then skimmed with a little scraper; the crucible is now seized with the casting tongs, and emptied in the following way :—

The mould or *form* for casting sheet brass consists of two slabs of granite, *a a*, *figs* 164, 165. They are 5½ feet long, 3 feet broad, 1 foot thick, and, for greater security, girt with iron bands, *b b*, 2 inches broad, 1¼ thick, and joined at the four corners with bolts and nuts. The mould rests upon an oaken block, *c*, 3½ feet long, 2⅙ broad, and 1¼ thick, which is suspended at each end upon gudgeons, in bearing blocks, placed under the foundry floor, *d d*, in the casting pit, *e e*. This is lined with bricks; and is 6⅞ feet long, 3½ broad, and 2 deep; upon the two long side walls of the pit, the bearing blocks are laid, which support the gudgeons. The swing-blocks are 10 inches long, 18 inches broad, 15 inches thick, and are somewhat rounded upon their back edge, so that the casting frame may slope a little to the horizon. To these blocks two cross wooden arms, *f f*, are mortised, upon which the under slab rests freely, but so as to project about 5 inches

backwards over the block, to secure an equipoise in the act of casting. *g g* are bars placed at both of the long sides, and one of the ends, between the slabs, to determine the
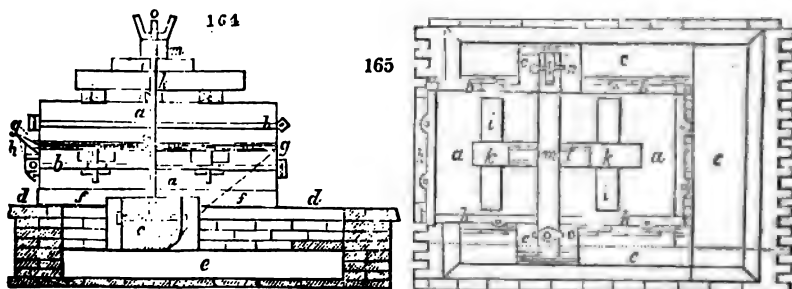
thickness of the brass-plate. Upon the other slab the gate *h* is fastened, a sheet of iron 6 inches broad, which has nearly the shape of a parallel trapezium (lozenge), and slopes a little towards the horizon. It serves for setting the casting pot upon in the act of pouring out, and renders its emptying more convenient. That gate (*steinmaul*) is coated with a mixture of loam and hair. The upper slab is secured to the under one in its slanting position by an *armor* or binding. This consists of the tension bars of wood, *i k l m*, of the iron bars *n*, (3 to 3½ inches broad, 1½ inch thick, see the top view, *fig.* 165,) of a rod with holes and pins at its upper end, and of the iron screw spindle *o*. The mode in which these parts act may be understood from inspection of the figure. In order to lift the upper slab from the under one, which is effected by turning it round its edge, a chain is employed, suspending two others, connected with the slab. The former passes over a pulley, and may be pulled up and down by means of a wheel and axle, or with the aid of a counterweight. Upon each of the two long sides of the slab there are two iron rings, to which the ends of the chains may be hooked. The casting faces of the slab must be coated with a layer of finely ground loam ; the thinner the better.

When calamine is employed, ½ cwt. of copper, ⅔ cwt. of calamine, and ⅛ the volume of both of charcoal mixed, are put into 7 crucibles, and exposed to heat during 11 or 12 hours ; the product being from 70 to 72 lbs. of brass.

Brass-plate rolling. At Hegermühl there are two re-heating or annealing furnaces, one larger, 18 feet long, and another smaller, 8½ ; the hot chamber is separated from the fire place by iron beams, in such a way that the brass castings are played upon by the flames on both their sides. After each passage through the laminating press (rolls) they are heated anew, then cooled and laminated afresh, till they have reached the proper length. The plates are besmeared with grease before rolling.
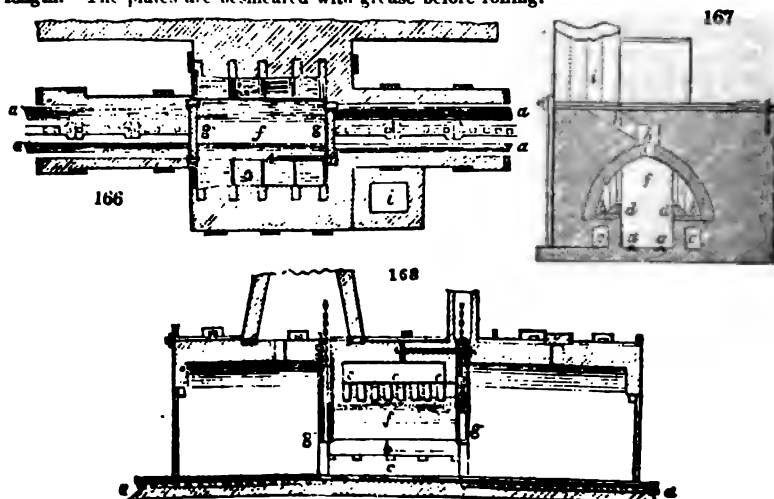

Fig. 166 shows the ground plan of the furnace and its railway ; *fig.* 167, the cross section ; and *fig.* 168, the section lengthwise ; *a a*, the iron way bars or rails upon the floor of the

foundry, for enabling the wheels of the wagon-frame to move readily backward and forward; *b b*, the two grates; *c c*, the ash pits; *d d*, the fire beams; *e e e*, vents in the roof of the hot chamber *f*; *g g*, two plates for shutting the hot chamber; *h*, the flue; *i*, the chimney. After the rolling, the sheets, covered with a black oxyde of copper, are plunged into a mother water of the alum works for a few minutes, then washed in clean water, and, lastly, smeared with oil, and scraped with a blunt knife.

In rough brass and brass wares, no less than 16,240 cwts. were manufactured in the Prussian States in the year 1832.

For musical purposes, the brass wire made in Berlin has acquired great and merited celebrity; but that of Birmingham is now preferred, even by foreigners.

BRASS COLOR, for staining glass, is prepared by exposing for several days thin plates of brass upon tiles in the *leer* or annealing arch of the glass-house, till it be oxydized into a black powder, aggregated in lumps. This being pulverized and sifted, is to be again well calcined for several days more, till no particles remain in the metallic state; when it will form a fine powder of a russet brown color. A third calcination must now be given, with a carefully regulated heat; its quality being tested from time to time by fusion with some glass. If it makes the glass swell, and intumesce, it is properly prepared; if not, it must be still farther calcined. Such a powder communicates to glass, greens of various tints, passing into turquoise.

When thin narrow strips of brass are stratified with sulphur in a crucible, and calcined at a red heat, they become friable, and may be reduced to powder. This being sifted and exposed upon tiles in a reverberatory furnace for ten or twelve days, becomes fit for use, and is capable of imparting a calcedony, red, or yellow tinge to glass by fusion, according to the mode and proportion of using it.

The glass-makers' red color may be prepared by exposing small plates of brass to a moderate heat in a reverberatory furnace, till they are thoroughly calcined, when the substance becomes pulverulent, and assumes a red color. It is then ready for immediate use.

BRASS COLOR, as employed by the colormen to imitate brass, is of two tints, the red or bronze, and the yellow like gilt brass. Copper filings, mixed with red ochre or bole, constitute the former; a powdered brass imported from Germany, is used for the latter. Both must be worked up with varnish after being dried with heat, and then spread with a flat camel-hair brush evenly upon the surface of the object. The best varnish is composed of 20 ounces of spirits of wine, 2 ounces of shellac, and 2 ounces of sandarach, properly dissolved. See VARNISH. Only so much of the brass powder and varnish should be mixed at a time as is wanted for immediate use.

BRASS FOIL. Dutch leaf, called *Knitter* or *Rauschgold* in Germany, is made from a very thin sheet brass, beat out under a hammer worked by water power, which gives 300 or 400 strokes per minute: from 40 to 80 leaves being laid over each other. By this treatment, it acquires its characteristic solidity and lustre. See above, the process for converting the copper superficially into brass by the fumes of zinc.

BRAZING. (*Braser*, Fr.; *Messing-lothung*, Germ.) The soldering together of edges of iron, copper, brass, &c., with an alloy consisting of brass and zinc, sometimes with a little tin or silver. The surfaces to be thus united must be filed perfectly bright, and not be soiled with the fingers or in any other way. The granular or nearly pulverulent alloy is usually wetted with a paste of ground borax and water, applied in this state, dried, and then exposed carefully to bright ignition at a clear forge fire. Some workmen enclose the part to be soldered in a clay lute, but others prefer leaving it uncovered, that they may see when the solder has flowed freely, and entered into all the seams.

BRAZIL-WOOD. (*Bois de Fernambouc*, Fr.; *Brasilienholz*, Germ.) This dye-wood derives its name from the part of America whence it was first imported. It has also the names Fernambuca, wood of Saint Martha, and of Sapan, according to the places which produce it. Linnæus distinguishes the tree which furnishes the Brazil-wood by the name of *Cæsalpinia crista*. It commonly grows in dry places among rocks. Its trunk is very large, crooked, and full of knots. It is very hard, susceptible of a fine polish, and sinks in water. It is pale when newly cleft, but becomes red on exposure to the air.

It has different shades of red and orange. Its goodness is determined particularly by its density. When chewed, a saccharine taste is perceived. It may be distinguished from red saunders wood, as the latter does not yield its color to water.

Boiling water extracts the whole coloring matter of Brazil-wood. If the ebullition be long enough continued, it assumes a fine red color. The residuum appears black. In this case, an alkali may still extract much coloring matter. The solution in alcohol or ammonia is still deeper than the preceding.

The decoction of Brazil-wood, called juice of Brazil, is observed to be less fit for dyeing when recent, than when old or even fermented. By age, it takes a yellowish-

red color. For making this decoction, Hellot recommends to use the hardest water; but it should be remarked, that this water deepens the color in proportion to the earthy salts which it contains. After boiling this wood reduced to chips, or, what is preferable, to powder, for three hours, this first decoction is poured into a cask. Fresh water is poured on the wood, which is then made to boil for three hours, and mixed with the former. When Brazil-wood is employed in a dyeing bath, it is proper to enclose it in a thin linen bag, as well as all the dye-woods in general.

Wool immersed in the juice of Brazil takes but a feeble tint, which is speedily destroyed. It must receive some preparations.

The wool is to be boiled in a solution of alum, to which a fourth or even less of tartar is added, for a larger proportion of tartar would make the color yellowish. The wool is kept impregnated with it for at least eight days, in a cool place. After this, it is dyed in the Brazil juice with a slight boiling. But the first coloring particles that are deposited, afford a less beautiful color; hence it is proper to pass a coarser stuff previously through the bath. In this manner a lively red is procured, which resists pretty well the action of the air.

Brazil-wood is made use of for dyeing silk what is called false crimson, to distinguish it from the crimson made by means of cochineal, which is much more permanent.

The silk should be boiled at the rate of 20 parts of soap per cent., and then alumed. The aluming need not be so strong as for the fine crimson. The silk is refreshed at the river, and passed through a bath more or less charged with Brazil juice, according to the shade to be given. When water free from earthy salts is employed, the color is too red to imitate crimson; this quality is given it by passing the silk through a slight alkaline solution, or by adding a little alkali to the bath. It might, indeed, be washed in a hard water till it had taken the desired shade.

To make deeper false crimsons of a dark red, juice of logwood is put into the Brazil bath after the silk has been impregnated with it. A little alkali may be added, according to the shade that is wanted.

To imitate poppy or flame color, an annotto ground is given to the silk, deeper even than when it is dyed with carthamus. It is washed, alumed, and dyed with juice of Brazil, to which a little soap water is usually added.

The coloring particles of Brazil-wood are easily affected, and made yellow by the action of acids.

They thus become permanent colors. But what distinguishes them from madder and kermes, and approximates them to cochineal, is their reappearing in their natural color, when they are thrown down in a state of combination with alumina, or with oxyde of tin. These two combinations seem to be the fittest for rendering them durable. It is requisite, therefore, to inquire what circumstances are best calculated to promote the formation of these combinations, according to the nature of the stuff.

The astringent principle, likewise, seems to contribute to the permanence of the coloring matter of Brazil-wood; but it deepens its hue, and can only be employed for light shades.

The coloring particles of Brazil-wood are very sensible to the action of alkalis, which give them a purple hue; and there are several processes in which the alkalis, either fixed or volatile, are used for forming violets and purples. But the colors obtained by these methods, which may be easily varied according to the purpose, are perishable, and possess but a transient bloom. The alkalis appear not to injure the colors derived from madder, but they accelerate the destruction of most other colors.

In England and Holland the dye-woods are reduced to powder by means of mills erected for the purpose.

The bright fugitive red, called fancy red, is given to cotton by Nicaragua, or peach-wood, a cheap kind of Brazil-wood.

The cotton being scoured and bleached, is boiled with sumach. It is then impregnated with a solution of tin (at 5° Baumé, according to Vitalis). It should now be washed slightly in a weak bath of the dyeing wood, and, lastly, worked in a somewhat stale infusion of the peach or Brazil wood. When the temperature of this is lukewarm, the dye is said to take better. Sometimes two successive immersions in the bath are given. It is now wrung out, aired, washed in water, and dried.

M. Vitalis says, that his solution of tin is prepared with two ounces of tin and a pound of aqua regia made with two parts of nitric acid at 24° Baumé, and three parts of muriatic acid at 22°.

For a rose color, the cotton is alumed as usual, and washed from the alum. It then gets the tin mordant, and is again washed. It is now turned through the dye-bath, an operation which is repeated if necessary.

For purple, a little alum is added to the Brazil bath.

1. For amaranth, the cotton is strongly galled, dried, and washed.

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2. It is passed through the black cask (tonne au noir,) see BLACK DYE, till it has taken a strong gray shade.

3. It receives a bath of lime-water.

4. Mordant of tin.

5. Dyeing in the Brazil-wood bath.

6. The two last operations are repeated.

Dingler has endeavored to separate the coloring matter of the different sorts of Brazil-wood, so as to obtain the same tint from the coarser as from the best Pernambuco. His process consists in treating the wood with hot water or steam, in concentrating the decoction so as to obtain 14 or 15 pounds of it from 4 pounds of wood, allowing it to cool, and pouring into it two pounds of skim milk; agitating, then boiling for a few minutes, and filtering. The dun coloring matters are precipitated by the coagulation of the caseous substance. For dyeing, the decoctions must be diluted with water; for printing they must be concentrated, so that 4 pounds of wood shall furnish only 5 or 6 pounds of decoction, and the liquor may be thickened in the ordinary way. These decoctions may be employed immediately, as by this treatment they have acquired the same property as they otherwise could get only by being long kept. A slight fermentation is said to improve the color of these decoctions; some ground wood is put into the decoction to favor this process.

As gelatine produces no precipitate with these decoctions, they consequently contain no tannin. Gall-nuts, however, sumach, the bark of birch or alder, render the color of Brazil-wood more durable, upon alumed linen and cotton goods, but the shade is a little darker.

In dyeing wool with Pernambuco, the temperature of the bath should never be above 150° Fahr., since higher heats impair the color.

According to Dingler and Kurrer, bright and fast scarlet reds may be obtained upon wool, by preparing a decoction of 50 pounds of Brazil-wood in three successive boils, and setting the decoction aside for 3 or 4 weeks in a cool place; 100 pounds of the wool are then alumed in a bath of 22 pounds of alum and 11 pounds of tartar, and afterwards rinsed in cold water. Meanwhile we fill two thirds with water, a copper containing 30 pails, and heated to the temperature of 150° or 160° F. We pour in 3 pailfuls of the decoction, heat to the same point again, and introduce 30 pounds of wool, which does not take a scarlet, but rather a crimson tint. This being removed, 2 pails of decoction are put in, and 30 pounds of wool, which becomes scarlet, but not so fine as at the third dip. If the dyer strengthens the color a little at the first dip, a little more at the second, and adds at the third and fourth the quantity of decoction merely necessary, he will obtain a uniform scarlet tint. With 50 pounds of Pernambuco 1000 pounds of wool may be dyed scarlet in this way, and with the deposites another 100 may be dyed of a tile color. An addition of weld renders the color faster but less brilliant.

Kurkmach says the dye may be improved by adding some ox-gall to the bath.

In dyeing cotton the tannin and gallic acid are two necessary mordants, and the color is particularly bright and durable, when the cloth has been prepared with the oily process of Turkey red.

It is said that stale urine heightens the color of the Brazil dye when the ground wood is moistened with it.

The quantity of Brazil or Nicaragua wood imported into the United Kingdom in 1835, was 4,242 tons, whereof 1,811 were exported; of Brazilietto 230 tons. The duty upon the first article is 5s. per ton.

BREAD (Pain, Fr.; Brod, Germ.) is the spongy mass produced by baking the leavened or fermented dough of wheat or rye flour, at a proper heat. It is the principal food of highly civilized nations. The skilful preparation of this indispensable article constitutes the art of the Baker. Dough baked without being fermented constitutes cakes or biscuits; but not bread strictly speaking.

Pliny informs us, that barley was the only species of corn at first used for food; and even after the method of reducing it to flour had been discovered, it was long before mankind learned the art of converting it into cakes.

Ovens were first invented in the East. Their construction was understood by the Jews, the Greeks, and the Asiatics, among whom baking was practised as a distinct profession. In this art, the Cappadocians, Lydians, and Phoenicians, are said to have particularly excelled. It was not till about 580 years after the foundation of Rome, that these artisans passed into Europe. The Roman armies, on their return from Macedonia, brought Grecian bakers with them into Italy. As these bakers had handmills beside their ovens, they still continued to be called pistores, from the ancient practice of bruising the corn in a mortar; and their bakehouses were denominated pistoria. In the time of Augustus there were no fewer than 329 public bakehouses in Rome; almost the whole of which were in the hands of Greeks, who long continued the only persons in that city acquainted with the art of baking good bread.

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In nothing, perhaps, is the wise and cautious policy of the Roman government more remarkably displayed, than in the regulations which it imposed on the bakers within the city. To the foreign bakers who came to Rome with the army from Macedonia, a number of freedmen were associated, forming together an incorporation from which neither they nor their children could separate, and of which even those who married the daughters of bakers were obliged to become members. To this incorporation were intrusted all the mills, utensils, slaves, animals, every thing, in short, which belonged to the former bakehouses. In addition to these, they received considerable portions of land; and nothing was withheld, which could assist them in pursuing, to the best advantage, their highly prized labors and trade. The practice of condemning criminals and slaves, for petty offences, to work in the bakehouse, was still continued; and even the judges of Africa were bound to send thither, every five years, such persons as had incurred that kind of chastisement. The bakehouses were distributed throughout the fourteen divisions of the city, and no baker could pass from one into another without special permission. The public granaries were committed to their care; they paid nothing for the corn employed in baking bread that was to be given in largess to the citizens; and the price of the rest was regulated by the magistrates. No corn was given out of these granaries except for the bakehouses, and for the private use of the prince. The bakers had besides private granaries, in which they deposited the grain, which they had taken from the public granaries for immediate use; and if any of them happened to be convicted of having diverted any portion of the grain to another purpose, he was condemned to a ruinous fine of five hundred pounds weight of gold.

Most of these regulations were soon introduced among the Gauls; but it was long before they found their way into the more northern countries of Europe. Borrichius informs us that in Sweden and Norway, the only bread known, so late as the middle of the 16th century, was unleavened cakes kneaded by the women. At what period in our own history the art of baking became a separate profession, we have not been able to ascertain; but this profession is now common to all the countries in Europe, and the process of baking is also nearly the same.

The French, who particularly excel in the art of baking, have a great many different kinds of bread. Their *pain bis*, or brown bread, is the coarsest kind of all, and is made of coarse groats mixed with a portion of white flour. The *pain bis blanc*, is a kind of bread between white and brown, made of white flour and fine groats. The *pain blanc*, or white bread, is made of white flour, shaken through a sieve after the finest flour has been separated. The *pain mollet*, or soft bread, is made of the purest flour without any admixture. The *pain chaland*, or customers' bread, is a very white kind of bread, made of pounded paste. *Pain chapelé*, is a small kind of bread, with a well-beaten and very light paste, seasoned with butter or milk. This name is also given to a small bread, from which the thickest crust has been removed by a knife. *Pain cornu*, is a name given by the French bakers to a kind of bread made with four corners, and sometimes more. Of all the kinds of small bread, this has the strongest and firmest paste. *Pain à la reine*, queen's bread, *pain à la Sigovie*, *pain chapelé*, and *pain cornu*, are all small kinds of bread, differing only in the lightness or thickness of the paste. *Pain graau* is a small very white bread made now in Paris, from the flour separated after a slight grinding from the best wheat. Such flour is in hard granular particles.

In this country we have fewer varieties of bread, and these differ chiefly in their degrees of purity. Our white or fine bread is made of the purest flour; our wheaten bread, of flour with a mixture of the finest bran; and our household bread, of the whole substance of the grain without the separation either of the fine flour or coarse bran. We have also symnel bread, manchet or roll bread, and French bread, which are all made of the purest flour from the finest wheat; the roll bread being improved by the addition of milk, and the French bread by the addition of eggs and butter. To these may be added gingerbread, a cake made of flour, with almonds, liquorice, aniseed, rose-water, and sugar or treacle; and mastlin bread, made of wheat and rye, or sometimes of wheat and barley. We have various kinds of small bread, having various names, according to their various forms. They are, in general, extremely light, and are sweetened with sugar, currants, and other palatable ingredients. In Scotland there is a cake called *short bread*, made from a pretty thick dough, enriched with butter, sweetened with sugar, and seasoned with orange peel, or other kinds of spices.

The process of making bread is nearly the same in all the countries of modern Europe; though the materials of which it is composed vary with the farinaceous productions of different climates and soils. The flour of wheat is most generally employed for this purpose, wherever that vegetable can be reared. This flour is composed of a small portion of mucilaginous saccharine matter, soluble in cold water, from which it may be separated by evaporation; of a great quantity of starch, which is scarcely soluble in cold water, but capable of combining with that fluid by means of heat; and an adhesive gray substance called gluten, insoluble in water, ardent spirit, oil, or ether, and resembling an animal

substance in many of its properties. Flour kneaded with water, forms a tough and rather indigestible paste containing all the constituent parts which we have enumerated. Heat produces a considerable change on the glutinous part of this compound, and renders it more easy of mastication and digestion. Still, however, it continues heavy and tough, compared with bread which is raised by leaven or yeast. Leaven is nothing more than a piece of dough, kept in a warm place till it undergoes a process of fermentation; swelling, becoming spongy, or full of air bubbles, at length disengaging an acidulo-spirituous vapor, and contracting a sour taste. When this leaven is mingled in proper proportions with fresh-made dough, it makes it rise more readily and effectually than it would do alone, and gives it at the same time a greater degree of firmness. Upon the quality of the leaven employed, the quality of the bread materially depends.

The principal improvement which has been made on bread in modern times, is the substitution of yeast or barm in place of common leaven. This yeast is the viscid froth that rises to the surface of beer, in the first stage of its fermentation. When mixed with the dough, it makes it rise much more speedily and effectually than ordinary leaven, and the bread is of course much lighter, and freer from that sour and disagreeable taste which may often be perceived in bread raised with leaven, either because too much is mingled with the paste, or because it has been allowed to advance too far in the process of fermentation.

Bread properly raised and baked differs materially from unleavened cakes, not only in being less compact and heavy, and more agreeable to the taste, but in losing its tenacious and glutinous qualities, and thus becoming more salutary and digestible.

We possess several analyses of wheat flour. Ordinary wheat (*triticum hybernum mixed with triticum turgidum*) contains, according to the analyses made by Vauquelin of several species of wheat flour, the following substances :—

Species of Wheat.	Water.	Gluten.	Starch.	Sugar.	Gum.	Bran.	Total.	Water of dough
French wheat flour - -	10·0	10·96	71·49	4·72	3·32	-	100·49	50·3
Hard wheat of Odessa flour - - - - - -	12·0	14·55	56·50	8·48	4·90	2·3	98·73	51·2
Soft wheat of Odessa flour - - - - - -	10·0	12·00	62·00	7·56	5·80	1·2	98·42	54·8
Same sort of flour - -	8·0	12·10	70·84	4·90	4·60	-	100·41	37·4
Same sort of flour - -	12·0	7·30	72·00	5·42	3·30	-	100·02	37·2
Wheat of the French bakers - - - - -	10·0	10·20	72·80	4·20	2·80	-	100·00	40·5
Flour of the Paris hospitals (2d quality) -	8·0	10·30	71·20	4·80	3·60	-	97·90	57·8
Ditto (3d quality) - -	12·0	9·02	67·78	4·80	4·60	2·0	100·21	37·8

The following table of analyses merits also a place here.

Species of Flour.	Water.	Gluten.	Starch.	Sugar.	Gummigluten.	Albumen.	Bran.
Flour of the triticum spelta	1	22·	74·	5·50	1·	1·50	
Ditto triticum hybernum	1	24·	68·	5·0	1·	1·50	
Ditto common wheat - -	-	12·5	74·5	12·	2·		
Ditto wheat and rye mixed (mastlin) - -	6	9·80	75·50	4·22	3·28	-	1·2

The first two of the above analyses were made by Vogel, the third by Proust, and the fourth by Vauquelin.

Analyses of the flour of some other corns.

Species of Flour.	Starch.	Mucilage.	Gluten.	Albumen.	Sugar.	Husk.	Hordein.
White oatmeal - - -	59·00	2·5	-	4·30	Of a fat oil, 8·25 2		
Barley meal - - - -	32·00	9·	3·	-	Of resin, 2	-	55.

The first analysis is by Vogel, the second by Proust.

It deserves to be remarked, that the flour of Odessa contains a much greater quantity of sugar than the French flour. The substance indicated in the preceding table by the name of gluten, is the gluten of Beccaria; that is to say, a mixture of gluten and vegetable

albumen. The gum of wheat is not quite identical with ordinary gum. It is a brown azotized substance, which, when treated by nitric acid, affords no mucic acid, but oxalic acid and the bitter principle of Welter. It contains besides superphosphate of lime.

The last column of the first table exhibits the quantity of water necessary to convert the flour into dough of the ordinary consistence, and it is usually proportional to the quantity of gluten. The hard wheat of Odessa forms an exception in this respect; the reason of the difference being that the starch contained in this flour is not as in ordinary flour in a fine powder, but in small transparent grains, which resemble pounded gum, and absorb less water than pulverulent starch.

The *triticum monococcon*, according to Zenneck, contains in its unsifted flour, 16·334 of gluten and vegetable albumen; 64·838 of starch; 11·347 of gum, sugar, and extractive; 7·481 of husks. The sifted flour affords 15·536 of gluten and vegetable albumen; 76·459 of starch; 7·198 of sugar, gum, and extractive; 0·807 of husky matter. It is difficult to conceive how such great quantities of gluten, albumen, and extractive matter could disappear in the sifting. The triticum spelta contains in 100 parts of the finest flour, 22·5 of a soft and humid gluten, mixed with vegetable albumen; 74 of starch, and 5·5 of sugar. Here we have an excess of 2 parts in the 100.

Wheat furnishes very little ashes by incineration, not more than 0·15 per cent. of the weight; containing superphosphates of soda, lime, and magnesia.

The object of baking is to combine the gluten and starch of the flour into a homogeneous substance, and to excite such a vinous fermentative action, by means of its saccharine matter, as shall disengage abundance of carbonic acid gas in it for making an agreeable, soft, succulent, spongy, and easily digestible bread. The two evils to be avoided in baking are hardness on the one hand, and pastiness on the other. Well-made bread is a chemical compound, in which the gluten and starch cannot be recognised or separated, as before, by a stream of water. When flour is kneaded into a dough, and spread into a cake, this cake, when baked, will be horny if it be thin, or if thick, will be tough and clammy; whence we see the value of that fermentative process, which generates thousands of little cells in the mass or crumb, each of them dry, yet tender and succulent, through the intimate combination of the moisture. By this constitution it becomes easily soluble in the juices of the stomach, or, in other words, light of digestion. It is moreover much less liable to turn sour than cakes made from unfermented dough.

Rye, which also forms a true spongy bread, though inferior to that of wheat, consists of similar ingredients; namely, 61·07 of starch; 9·48 of gluten; 3·28 of vegetable albumen; 3·28 of uncrystallizable sugar; 11·09 of gum; 6·38 of vegetable fibre; the loss upon the 100 parts amounted to 5·62, including an acid whose nature the analyst, M. Einhof, did not determine. Rye flour contains also several salts, principally the phosphates of lime and magnesia. This kind of grain forms a dark-colored bread, reckoned very wholesome: comparatively little used in this country, but very much in France, Germany, and Belgium.

Dough fermented with the aid either of leaven or yeast, contains little or none of the saccharine matter of the flour, but in its stead a certain portion, nearly half its weight of spirit, which imparts to it a vinous smell, and is volatilized in the oven; whence it might be condensed into a crude weak alcohol, on the plan of Mr. Hick's patent, were it worth while. But the increased complexity of the baking apparatus will probably prove an effectual obstacle to the commercial success of this project, upon which already upwards of £20,000 sterling have been squandered.

That the sugar of the flour is the true element of the fermentation preposterously called panary, which dough undergoes, and that the starch and gluten have nothing to do with it, may be proved by decisive experiments. The vinous fermentation continues till the whole sugar is decomposed, and no longer: when, if the process be not checked by the heat of baking, the acetous fermentation will supervene. Therefore, if a little sugar be added to a flour which contains little or none, its dough will become susceptible of fermenting, with extrication of gas, so as to make spongy succulent bread. But since this sponginess is produced solely by the extrication of gas, and its expansion in the heat of the oven, any substance capable of emitting gas, or of being converted into it under these circumstances, will answer the same purpose. Were a solution of bicarbonate of ammonia obtained by exposing the common sesqui-carbonate in powder for a day to the air, incorporated with the dough, in the subsequent firing it will be converted into vapor, and in its extrication render the bread very porous. Nay, if water highly impregnated with carbonic acid gas be used for kneading the dough, the resulting bread will be somewhat spongy. Could a light article of food be prepared in this way, then as the sugar would remain undecomposed, the bread would be so much the sweeter, and the more nourishing. How far a change propitious to digestion takes place in the constitution of the starch and gluten, during the fermentative action of the dough, has not been hitherto ascertained by precise experiments. Medical practitioners, who

derive an enormous revenue from dyspepsia, should take some pains to investigate this subject.

Dr. Colquhoun, in his able essay upon the art of making bread, has shown that its texture, when prepared by a sudden formation and disengagement of elastic fluid generated within the oven, differs remarkably from that of a loaf which has been made after the preparatory fermentation with yeast. Bread which has been raised with the common carbonate of ammonia, as used by the pastry-cooks, is porous no doubt, but not spongy with vesicular spaces, like that made in the ordinary way. The former kind of bread never presents that air-cell stratification which is the boast of the Parisian baker, but which is almost unknown in London. I have found it, moreover, very difficult to expel by the oven the last portion of the ammonia, which gives both a tinge and a taste to the bread.· I believe, however, that the bicarbonate would be nearly free from this objection, which operates so much against the sesqui-carbonate of the shops.

In opposition to Mr. Edlin's account of the excellent quality of bread made by impregnating dough with carbonic acid gas,[*] Dr. Colquhoun adduces Vogel's experiments, which show that such dough, when baked, after having been kept in a warm situation during the usual time, afforded nothing better than a hard cake, which had no resemblance to common bread. Vogel further states. as illustrative of the general necessity of providing a sufficient supply of disengaged elastic fluid within the dough, before baking it at all, that when he made various attempts to form a well-raised vesicular loaf, within the oven, by mixing flour with carbonate of magnesia, or with zinc filings, and then kneading it into a paste by means of water, acidulated with sulphuric acid, he always met with complete failure and disappointment. Dr. Colquhoun performed a series of well-devised experiments on this subject, which fully confirmed Vogel's results, and prove that a proper spongy bread cannot be made by the agency of either carbonic acid water, or of mixtures of sesqui-carbonate of soda, and tartaric acid. The bread proved doughy and dense in every case, though less so with the latter mixture than the former. No loaf bread can, indeed, be well made by any of these two extemporaneous systems, because they are inconsistent with the thorough kneading of the dough. It is this process which renders dough at once elastic enough to expand when carbonic acid gas is generated within it, and cohesive enough to confine the gas when it is generated. The whole gas of the loaf is disengaged in its interior by a continuous fermentation, after all the processes of kneading have been finished; for the loaf, after being kneaded, weighed out, and shaped, is set aside till it expands gradually to double its bulk, before it is put into the oven. But when a dough containing sesqui-carbonate of soda is mixed with one containing muriatic acid, in due proportions to form the just dose of culinary salt, the gas escapes during the necessary incorporation of the two, and the bread formed from it is dense and hard. Dr. Whiting has, however, made this old chemical process the subject of a new patent for baking bread.

When the baker prepares his dough, he takes a portion of the water needed for the batch, having raised its temperature to from 70° to 100° F., dissolves a certain proportion of his salt in it, then adds the yeast, and a certain quantity of his flour. This mixture, called the *sponge*, is next covered up in the small kneading-trough, alongside of the large one, and let alone for *setting* in a warm situation. In about an hour, signs of vinous fermentation appear, by the swelling and heaving up of the sponge, in consequence of the generation of carbonic acid; and if it be of a semi-liquid consistence, large air bubbles will force their way to the surface, break, and disappear in rapid succession. But when the *sponge* has the consistence of thin *dough*, it confines the gas, becomes thereby equably and progressively inflated to double its original volume; when no longer capable of containing the pent-up air, it bursts and subsides. This process of rising and falling alternately might be carried on during twenty-four hours, but the baker has learned by experience to guard against allowing full scope to the fermentative principle. He generally interferes after the first, or at furthest after the second or third dropping of the sponge; for were he not to do so, the bread formed with such dough would be invariably found sour to the taste and the smell. Therefore he adds at this stage to the sponge the reserved proportions of flour, salt, and water, which are requisite to make the dough of the desired consistence and size; and next incorporates the whole together by a long and laborious course of kneading. When this operation has been continued till the fermenting and the fresh dough have been intimately blended, and till the glutinous matter of both is worked into such union and consistence that the mass becomes so tough and elastic as to receive the smart pressure of the hand without adhering to it, the kneading is suspended for some time. The dough is now abandoned to itself for a few hours, during which it continues in a state of active fermentation throughout its entire mass. Then it is subjected to a second but much less laborious kneading, in order to distribute the generated gas as evenly as possible

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[*] Treatise on the Art of Bread Making, p. 56.

among its parts, so that they may all partake equally of the vesicular structure. After this second kneading, the dough is weighed out into the portions suitable to the size of bread desired; which are of course shaped into the proper forms, and once more set aside in a warm situation. The continuance of the fermentation soon disengages a fresh quantity of carbonic acid gas, and expands the lumps to about double their pristine volume. These are now ready for the oven, and when they finally quit it in the baked state, are about twice the size they were when they went in. The generation of the due quantity of gas should be complete before the lumps are transferred to the oven; because whenever they encounter its heat, the process of fermentation is arrested; for it is only the previously existing air which gets expanded throughout every part of the loaf, swells out its volume, and gives it the *piled* and vesicular texture. Thus the well-baked loaf is composed of an infinite number of cellules filled with carbonic acid gas, and apparently lined with a glutinous membrane of a silky softness. It is this which gives the light, elastic, porous constitution to bread.

After suffering the fermentative process to exhaust itself in a mass of dough, and the dough to be brought into that state in which the addition of neither yeast, nor starch, nor gluten will produce any effect in restoring that action, if we mix in 4 per cent. of saccharine matter, of any kind, with a little yeast, the process of fermentation will immediately re-commence, and pursue a course as active and lengthened as at first, and cease about the same period.[*]

This experiment, taken in connexion with the facts formerly stated, proves that what was called panary fermentation, is nothing but the ancient and well-known process of the vinous fermentation of sugar, which generates alcohol. There seems to be but one objection to the adoption of this theory. After the loaf is baked, there is found in its composition nearly as much saccharine matter as existed in the flour before fermentation. M. Vogel states that in the baked bread there remains 3·6 parts of sugar, out of the 5 parts which it originally contained. Thus, in 100 parts of loaf bread prepared with wheaten flour, distilled water, and yeast without the admixture of any common salt, he found the following ingredients :—

Sugar - - -	3·6
Torrefied or gummy starch -	18·0
Starch - - -	53·5
Gluten, combined with a little starch, 20·75	

Exclusive of carbonic acid, muriate of lime, phosphate of lime, &c.

It must be borne in mind that in every loaf the process of fermentation has been prematurely checked by the baker's oven, and therefore the saccharine constituent can never be wholly decomposed. It seems certain, also, that by the action of gluten upon the starch in the early stage of the firing, a quantity of sugar will be formed by the saccharine fermentation; which we have explained in treating of BEER.

Several masses of dough were prepared by Dr. Colquhoun in which pure wheat starch was mixed with common flour, in various proportions. In some of the lumps this starch had been gelatinized, with the *minimum* of hot water, before it was added to the flour. After introducing the usual dose of salt, the dough was thoroughly kneaded, set apart for the proper period, allowed to ferment in the accustomed way, and then baked in the oven. In outward appearance, increase of bulk, and vesicular texture, none of them differed materially from a common loaf, baked along with them for the sake of comparison; except that when the starch considerably exceeded the proportion of flour in the lump, the loaf, though whiter, had not risen so well, being somewhat less vesicular. But, on tasting the bread of each loaf, those which contained most gelatinized starch were unexpectedly found to be the sweetest. The other loaves, into which smaller quantities of the gelatinized starch had been introduced, or only some dry starch, had no sweetish taste whatever to distinguish them from ordinary bread. These facts seem to establish the conclusion, that the presence of gelatinous starch in bread put into the oven, is a means of forming a certain portion of saccharine matter within the loaf, during the baking process. Now it is more than probable that gelatinized starch does exist, more or less, in all loaves which have been fermented by our usual methods, and hence a certain quantity of sugar will necessarily be generated at its expense, by the action of heat. Thus the difficulty started by M. Vogel is sufficiently solved; and there remains no doubt that, in the saccharine principle of flour, the fermentation has its origin and end, while dough is under fermentation.

The source of the sourness which supervenes in bread, under careless or unskilful hands, had been formerly ascribed to each of all the constituents of flour; to its gluten, its starch, and its sugar; but erroneously, as we now see : for it is merely the result of the second fermentation which always succeeds the vinous, when pushed improperly too far. It has been universally taken for granted by authors, that the acid thus generated

in dough is the acetic. But there appear good grounds to believe that it is frequently a less volatile acid, probably the lactic, particularly when the process has been tardy, from the imperfection of the yeast or the bad quality of the flour. The experiments of Vogel, Braconnot, and others, prove that the latter acid is generated very readily, and in considerable quantity during the spontaneous decomposition of a great many vegetable substances, when in a state of humidity. The presence of lactic acid would account for the curious fact, that the acidity of unbaked dough is much more perceptible to the taste than to the smell; while the sourness of the same piece of bread, after coming out of the oven, is, on the contrary, much more obvious to the olfactory organs than to the palate. But this is exactly what ought to happen, if the lactic acid contributes, in conjunction with the acetic, to produce the acescence of the dough. At the ordinary temperature of a bakehouse, the former acid, though very perceptible in the mouth, is not distinguishable by the nostrils; but as it is easily decomposed by heat, no sooner is it exposed to the high temperature of the oven, than it is resolved, in a great measure, into acetic acid,* and thus becomes more manifest to the sense of smell, and less to that of taste. This theory seems to explain satisfactorily all the phenomena accompanying the progress of fermentation in baker's dough, and also some of its results in the process of baking which do not easily admit of any other solution.

There are extremely simple and effectual methods for enabling the baker to adopt measures either to prevent or correct the evil of acescence, and these are to neutralize the acid by the due exhibition of an alkali, such as soda; or an alkaline earth, such as magnesia or chalk. And it affords a striking proof of how much the artisan has been accustomed to plod, uninquiring and uninformed, over the same ground, that a remedy so safe and so economical, should remain at this day unthought of and unemployed by most of the manufacturers of bread in the United Kingdom. The introduction of a small portion of carbonate of soda will rectify any occasional error in the result of the so called panary fermentation, and will, in fact, restore the dough to its pristine sweetness. The quantity of acetate of soda, which will be thus present in the bread, will be altogether inconsiderable; and as it has no disagreeable taste, and is merely aperient to the bowels in a very mild degree, it can form no objection in the eye of the public police. The restoration of dough thus tainted with acid, and its conversion into pleasant and wholesome bread, has been sufficiently verified by experiment. But, according to Mr. Edmund Davy, carbonate of magnesia may be used with still greater advantage, as during the slow action of the acid upon it, the carbonic acid evolved serves to open up and lighten bread which would otherwise be dense and doughy from the indifferent quality of the flour. Here, however, the dangerous temptation lies with a sordid baker to use cheap or damaged flour, and to rectify the bread made of it by chemical agents, innocent in themselves, but injurious as masks of a bad raw material. When sour yeast must be used, as sometimes happens with the country bakers, or in private houses at a distance from beer breweries, there can be no harm, but, on the contrary, much propriety, in correcting its acidity, by the addition of as much carbonate of soda to it as will effect its neutralization, but nothing more. When sour yeast has been thus corrected, it has been found, in practice, to possess its fermentative power unimpaired, and to be equally efficacious with fresh formed yeast, in making good palatable leaven.

We have seen that, in baking, about one fourth of the starch is converted into a matter possessing the properties of British gum (see STARCH), and also that the gluten, though not decomposed, has its particles disunited, and is not so tough and adhesive as it is in the flour. This principle is also, as we have said, useful in cementing all the particles of the dough into a tenacious mass, capable of confining the elastic fluid generated by the vinous fermentation of the sugar. Starch is the main constituent, the basis of nourishment in bread, as well as in all farinaceous articles of food. The albumen also of the wheat, being coagulated by the heat of the oven, contributes to the setting of the bread into a consistent elastic body.

In the mills in the neighborhood of London, no less than seven distinct sorts of flour are ground out of one quantity of wheat. These are for one quarter—

Fine flour	-	-	-	-	-	-	5 bushels	3 pecks.
Seconds	-	-	-	-	-	-	0	2
Fine middlings	-	-	-	-	-	0	1
Coarse middlings	-	-	-	-	0	0·5
Bran	-	-	-	-	-	-	3	0
Twenty-penny	-	-	-	-	-	3	0
Pollard	-	-	-	-	-	-	2	
							14	2·5

* Berzelius.

So that we have nearly a double bulk of flour, or 14 bushels and 2½ pecks from 8 bushels of wheat. In the sifting of the flour through the bolter, there is a fine white angular meal obtained called sharps, which forms the central part of the grain. It is consumed partly by the fine biscuit bakers. The bakers of this country were formerly bound by law to bake three kinds of bread, the *wheaten*, *standard wheaten*, and the *household*; marked respectively with a W, S W, and H, and if they omitted to make these marks on their bread they were liable to a penalty. The size of the loaves were usually peck, half-peck, quartern, and half-quartern; the weights of which, within 48 hours of their being baked, should have been respectively 17 lbs. 6 oz.; 8 lbs. 11 oz.; 4 lbs. 5 oz. 8 dr.; and 4 lbs. 2 oz. 14 dr. In general they weigh about one seventh more before they enter the oven, or they lose one seventh of their weight in baking. The French bread loses fully one sixth in the oven, owing chiefly to its more oblong thin shape, as compared to the cubical shape of the English bread. But this loss of weight is very variable, being dependant upon the quality of the wheaten flour, and the circumstances of baking. The present law in England defines the quartern loaf at 4 lbs., and subjects the baker to a penalty if the bread be one ounce lighter than the standard. Hence it leaves the baker, in self-defence, to leave it in rather a damp and doughy state. But there is much light bread sold in London. I have met with quartern loaves of 3 lbs. 10 oz. A sack of flour weighing 280 lbs. was presumed by the framers of our former parliamentary acts, for the assize of bread, to be capable of being baked into 80 loaves. If this proportion had been correct, one fifth part of our quartern loaf must consist of water and salt, and four fifths of flour. But in general, of good wheaten flour, three parts will take up one part of water; so that the sack of flour should have turned out, and actually did turn out, more than 80 loaves. At present with 4 lb. bread it may well yield 92 loaves.

The following statement of the system of baking at Paris, I received in 1835 from a very competent judge of the business.

1,000 kilogrammes of wheat=5 quarters*English, cost 200 fr., and yield 800 kilos. of flour of the best white quality, equivalent to 5$\frac{1}{10}$ sacks French. Hence the sack of flour costs 40 francs at the mill, and including the carriage to Paris, it costs 45 or 46 francs.

The profit of the flour dealer is about 3½ francs, and the sale price becomes from 43 to 50 francs.

Bread manufactured from the above.

	£	s.	d.	£	s.	d.
One day's work of an ordinary baker, who makes four batches in a day, consists of 3 sacks at 50 francs, or 2l. sterling each				6	0	0
Salt 2¾ lbs. at 2d. per lb.				0	0	5½
Yeast or leaven 3 lbs. at 5d.				0	1	3
Total cost of materials				6	1	8

Expenses of Baking.

	£	s.	d.	£	s.	d.
Three workmen at different rates of wages, 15 francs	0	12	0			
Fire-wood 0, as the charcoal produced pays for it						
General expenses, such as rent, taxes, interest of capital, &c.	0	12	0			
	1	4	0	= 1	4	0
				7	5	8

For this sum 315 loaves are made, being 105 for every sack of flour weighing 156·66 kilos. or 344¾ lbs. avoird. One loaf contains therefore $\frac{344.66}{105}$ = 3·282 lbs., and as 100 lbs. of flour in Parisian baking are reckoned to produce 127 lbs. of bread, each loaf will weigh 4·168 lbs., avoird., and will cost 7l. 5s. 8½d. divided by 315 = 5¼d. very nearly. The value of 315 loaves at the sale price of 6d. will be — — — — — — — 7 17 6

Upon this day's work the clear profit is therefore — — 0 11 6

A new baking establishment has been recently formed at the Royal Clarence Victualling Establishment at Weevil, near Portsmouth, upon a scale of magnitude nearly sufficient to supply the whole royal navy with biscuits, and that of a very superior description. The following account of it is taken from the United Service Journal. "It having been discovered that the flour supplied to government by contract, had in many instances been most shamefully adulterated, the corn is ground at mills comprised within the establishment, by which means the introduction of improper ingredients prevented, and precisely the proportion of bran which is requisite in the composition of good sea-biscuit is retained, and no more. The flour-mill is furnished with ten pairs

stones, by which 40 bushels of flour may be ground and dressed ready for baking, in an hour. The baking establishment consists of 9 ovens, each 13 feet long by 11 feet wide, and 17½ inches in height. These are each heated by separate furnaces, so constructed that a blast of hot air and fire sweeps through them, and gives to the interior the requisite dose of heat in an incredible short space of time. The first operation in making the biscuits consists in mixing the flour, or rather meal and water; 13 gallons of water are first introduced into a trough, and then a sack of the meal, weighing 280 lbs. When the whole has been poured in by a channel communicating with an upper room, a bell rings, and the trough is closed. An apparatus consisting of two sets of what are called knives, each set ten in number, are then made to revolve amongst the flour and water by means of machinery. This mixing operation lasts one minute and a half, during which time the double set of knives or stirrers makes twenty-six revolutions. The next process is to cast the lumps of dough under what are called the breaking-rollers,— huge cylinders of iron, weighing 14 cwt. each, and moved horizontally by the machinery along stout tables. The dough is thus formed into large rude masses 6 feet long by 3 feet broad, and several inches thick. At this stage of the business, the kneading is still very imperfect, and traces of dry flour may still be detected. These great masses of dough are now drawn out, and cut into a number of smaller masses about a foot and a half long by a foot wide, and again thrust under the rollers, which is repeated until the mixture is so complete that not the slightest trace of any inequality is discoverable in any part of the mass. It should have been stated that two workmen stand one at each side of the rollers, and as the dough is flattened out they fold it up, or double one part upon another, so that the roller at its next passage squeezes these parts together, and forces them to mix. The dough is next cut into small portions, and being placed upon large flat boards, is, by the agency of machinery, conveyed from the centre to the extremity of the baking-room. Here it is received by a workman, who places it under what is called the sheet roller, but which, for size, color, and thickness, more nearly resembles a blanket. The kneading is thus complete, and the dough only requires to be cut into biscuits before it is committed to the oven. The cutting is effected by what is called the cutting-plate, consisting of a net-work of 52 sharp-edged hexagonal frames, each as large as a biscuit. This frame is moved slowly up and down by machinery, and the workman, watching his opportunity, slides under it the above-described blanket of dough, which is about the size of a leaf of a dining-table; and the cutting-frame in its descent indents the sheet, but does not actually cut it through, but leaves sufficient substance to enable the workman at the mouth of the oven to jerk the whole mass of biscuits unbroken into it. The dough is prevented sticking to the cutting-frame by the following ingenious device: between each of the cutter-frames is a small flat open frame, moveable up and down, and loaded with an iron ball, weighing several ounces. When the great frame comes down upon the dough, and cuts out 52 biscuits, each of these minor frames yields to the pressure, and is raised up; but as soon as the great frame rises, the weight of the balls, acting upon the little frames, thrusts the whole blanket off, and allows the workmen to pull it out. One quarter of an hour is sufficient to bake the biscuit, which is afterwards placed for three days in a drying room, heated to 85° or 90°, which completes the process." The following statement of the performance of the machinery is taken from actual experiment; in 116 days, during 68 of which the work was continued for only 7½ hours; and during 48, for only 5¾ hours each day, in all 769 working hours, equal to 77 days of 10 hours each; the following quantity of biscuit was baked in the 9 ovens, viz.: 12,307 cwt. = 1,378,400 lbs. The wages of the men employed in baking this quantity amounted to 273*l*. 10*s*. 9½*d*.; if it had been made by hand, the wages would have been 933*l*. 9*s*. 10*d*.; saving in the wages of labor, 659*l*. 7*s*. 0½*d*. In this, is not included any part of the interest of the sum laid out upon the machine, or expended in keeping it in order. But in a very few years, at such an immense rate of saving, the cost of the engine and other machinery will be repaid. This admirable apparatus is the invention of T. T. Grant, Esq., storekeeper of the Royal Clarence Victualling Establishment, who, we believe, has been properly rewarded, by a grant of 2,000*l*. from government.

The labor of incorporating the ingredients of bread, viz., flour, water, and salt, or kneading dough, is so great as to have led to the contrivance of various mechanical modes of producing the same effect. One of the most ingenious is that for which a patent was obtained in August, 1830, by Mr. Edwin Clayton. It consists of a rotatory kneading trough, or rather barrel, mounted in bearings with a hollow axle, and of an interior frame of cast iron made to revolve by a solid axle which passes through the hollow one; in the frame there are cutters diagonally placed for kneading the dough. The revolving frame and its barrel are made to turn in contrary directions, so as greatly to save time and equalise the operation. This double action represents kneading by the two hands, in which the dough is inverted from time to time, torn asunder, and reunited in every different form. The mechanism will be readily understood from the following description.

Fig. 169 exhibits a front elevation of a rotatory kneading trough, constructed according to improvements specified by the patentee, the barrel being shown in section; a is the
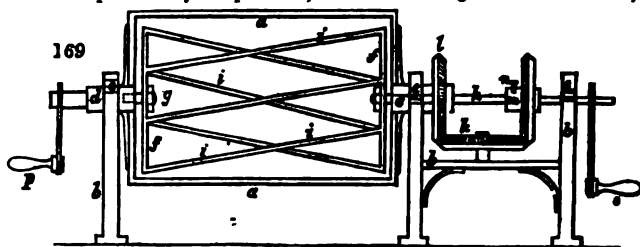
barrel, into which the several ingredients, consisting of flour, water, and yeast, are put, which barrel is mounted in the frame-work b, with hollow axles c and d, which hollow axles turn in suitable bearings at e; f is the revolving frame which is mounted in the interior of the barrel a, by axles g and h. The ends of this revolving frame are fastened, or braced together by means of the oblique cutters or braces i, which act upon the dough when the machine is put in motion, and thus cause the operation of kneading.

Either the barrel may be made to revolve without the rotatory frame, or the rotatory frame without the barrel, or both may be made to revolve together, but in opposite ways. These several motions may be obtained by means of the gear-work, shown at k, l, and m, as will be presently described.

If it be desired to have the revolving motion of the barrel and rotatory frame together, but in contrary directions, that motion may be obtained by fastening the hollow axle of the wheel m, by means of a screw n, to the axle h, of the rotatory frame f, tight, so as they will revolve together, the other wheels k and l being used for the purpose of reversing the motion of the barrel. It will then be found that by turning the handle e, the two motions will be obtained.

If it be desired to put the rotatory frame f, only, into motion, that action will be obtained by loosening the screw n, upon the axle of the wheel m, when it will be found that the axle h will be made to revolve freely by means of the winch o, without giving motion to the wheels k, l, and m, and thus the barrel will remain stationary. If the rotatory action of the barrel be wanted, it will be obtained by turning the handle p, at the reverse end of the machine, which, although it puts the gear at the opposite end of the barrel into motion, yet as the hollow axle of the wheel m is not fastened to the axle h, by the screw n, these wheels will revolve without carrying round the frame f.

M. Kuhlmann, Professor of Chemistry at Lille, having been called upon several times by the courts of justice to examine by chemical processes bread suspected of containing substances injurious to health, collected some interesting facts upon the subject, which were published under the direction of the central council of salubrity of the department du Nord.

For some time public attention had been drawn to an odious fraud committed by a great many bakers in the north of France and in Belgium—the introduction of a certain quantity of sulphate of copper into their bread. When the flour was made from bad grain this adulteration was very generally practised, as was proved by many convictions and confessions of the guilty persons. When the dough does not rise well in the fermentation (le pain poussé plat), this inconvenience was found to be obviated by the addition of blue vitriol, which was supposed also to cause the flour to retain more water. The quantity of blue water added is extremely small, and it is never done in presence of strangers, because it is reckoned a valuable secret. It occasions no economy of yeast, but rather the reverse. In a litre (about a quart) of water, an ounce of sulphate of copper is dissolved; and of this solution a wine-glass full is mixed with the water necessary for 50 quartern or 4 pound loaves.

M. Kuhlmann justly observes, that there can be no safety whatever to the public when such a practice is permitted, because ignorance and avarice are always apt to increase the quantity of the poisonous water. In analyses made by him and his colleagues, portions of bread were several times found so impregnated with the above salt that they had acquired a blue color, and presented occasionally even small crystals of the sulphate. By acting on the poisoned bread with distilled water, and testing the water with ferro-cyanate (prussiate) of potash, the reddish brown precipitate or tint characteristic of copper will appear even with small quantities. Should the noxious impregnation be still more minute, the bread should be treated with a very dilute nitric acid, either directly or after incineration in a platinum capsule, and the solution, when concentrated by evaporation, should be tested by the ferro-cyanate of potash. In this way, a one seventy thousandth part of sulphate of copper may be detected.

M. Kuhlmann deduces, from a series of experiments on baking with various small quantities of sulphate of copper, that this salt exercises an extremely energetic action upon the fermentation and rising of the dough, even when not above one seventy thousandth part of the weight of the bread is employed; or one grain of sulphate for ten pounds of bread. The proportion of the salt which makes the bread rise best is one twenty thousandth, or one grain in three pounds of bread. If much more of the sulphate be added, the bread becomes moist, less white, and acquires a peculiar disagreeable smell like that of leaven. The increase of weight by increased moisture may amount to one sixteenth without the bread appearing softer, in consequence of the solidifying quality of the copper; for the acid does not seem to have any influence; as neither sulphate of soda, sulphate of iron, nor sulphuric acid have any analogous power. Alum operates like blue vitriol on bread, but larger quantities of it are required. It *keeps water*, and *raises well*, to use the bakers' terms.

When alum is present in bread it may be detected by treating the bread with distilled water, filtering the water first through calico, and next through filtering paper, till it becomes clear; then dividing it into two portions, and into the one pouring a few drops of nitrate or muriate of barytes, and into the other a few drops of water of ammonia. In the former a heavy white precipitate indicating sulphuric acid will appear, and in the latter a light precipitate of alumina, redissoluble by a few drops of solution of caustic potash.

When chalk or Paris plaster is used to sophisticate flour, they may be best detected by incinerating the bread made of it, and examining the ashes with nitric acid, which will dissolve the chalk with effervescence, and the Paris plaster without. In both cases the calcareous matter may be demonstrated in the solution, by oxalic acid, or better by oxalate of ammonia.

In baking puff-paste the dough is first kneaded along with a certain quantity of butter, then rolled out into a thin layer, which is coated over with butter, and folded face-wise many times together, the upper and under surfaces being made to correspond. This stratified mass is again rolled out into a thin layer, its surface is besmeared with butter, and then it is folded face-wise as before. When this process is repeated ten or a dozen times, the dough will consist of many hundred parallel laminæ, with butter interposed between each pair of plates. When a moderately thick mass of this is put into the oven, the elastic vapor disengaged from the water and the butter, diffuses itself between each of the thin laminæ, and causes them to swell into what is properly called puff-paste, being an assemblage of thin membranes, each dense in itself, but more or less distinct from the other, and therefore forming apparently, but not really, light bread.

One of the most curious branches of the baker's craft is the manufacture of gingerbread, which contains such a proportion of molasses, that it cannot be fermented by means of yeast. Its ingredients are flour, molasses or treacle, butter, common potashes, and alum. After the butter is melted, and the potashes and alum are dissolved in a little hot water, these three ingredients, along with the treacle, are poured among the flour, which is to form the body of the bread. The whole is then incorporated by mixture and kneading into a stiff dough. Of these five constituents the alum is thought to be the least essential, although it makes the bread lighter and crisper, and renders the process more rapid; for gingerbread dough requires to stand over several days, sometimes 8 or 10, before it acquires that state of porosity which qualifies it for the oven. The action of the treacle and alum on the potashes in evolving carbonic acid, seems to be the gasefying principle of gingerbread; for if the carbonate of potash is withheld from the mixture, the bread, when baked, resembles in hardness a piece of wood.

Treacle is always acidulous. Carbonate of magnesia and soda may be used as substitutes for the potashes. Dr. Colquhoun has found that carbonate of magnesia and tartaric acid may replace the potashes and the alum with great advantage, affording a gingerbread fully more agreeable to the taste, and much more wholesome than the common kind, which contains a notable quantity of potashes. His proportions are one pound of flour, a quarter of an ounce of carbonate of magnesia, and one eighth of an ounce of tartaric acid; in addition to the treacle, butter, and aromatics, as at present used. The acid and alkaline earth must be well diffused through the whole dough. The magnesia should, in fact, be first of all mixed with the flour. Pour the melted butter, the treacle, and the acid dissolved in a little water all at once among the flour, and knead into a consistent dough, which being set aside for half an hour or an hour will be ready for the oven, and should never be kept unbaked more than 2 or 3 hours. The following more complete recipe is given by Dr. Colquhoun, for making thin gingerbread cakes:—

Flour	1 lb.
Treacle	0½
Raw sugar	0¼

Butter	2 oz.
Carbon. magnesia	$0\frac{1}{4}$
Tartaric acid	$0\frac{1}{4}$
Ginger	$0\frac{1}{4}$
Cinnamon	$0\frac{1}{4}$
Nutmeg	1

This compound has rather more butter than common thin gingerbread.

I shall here insert a passage from my Dictionary of Chemistry, as published in 1821; as it may prove interesting to many of my present readers.

"Under *Process of Baking*, in the Supplement to the Encyclopedia Britannica, we have the following statement:—'An ounce of alum is then dissolved over the fire in a tin pot, and the solution poured into a large tub, called by the bakers the seasoning-tub. Four pounds and a half of salt are likewise put into the tub, and a pailful of hot water.'—*Foot note on this passage*.—' In London, where the goodness of bread is estimated entirely by its whiteness, it is usual with those bakers who employ flour of an inferior quality, to add as much alum as common salt to the dough; or, in other words, the quantity of salt added is diminished one half, and the deficiency supplied by an equal weight of alum. This improves the look of the bread very much, rendering it much whiter and firmer.'"

In a passage which we shall presently quote, our author represents the bakers of London in a conspiracy to supply the citizens with bad bread. We may hence infer that the full allowance he assigns of $2\frac{1}{4}$ pounds of alum for every $2\frac{1}{4}$ pounds of salt, will be adopted in converting the sack of flour into loaves. But as a sack of flour weighs 280 pounds, and furnishes on an average 80 quartern loaves, we have $2\frac{1}{4}$ pounds divided by 80, or $\frac{15750 \text{ grains}}{80}$ = 197 grains, for the quantity present, by this writer, in a London quartern loaf. Yet in the very same page (39th of vol. ii.) we have the following passage: "Alum is not added by all bakers. The writer of this article has been assured by several bakers of respectability, both in Edinburgh and Glasgow, on whose testimony he relies, and who made excellent bread, that they never employed any alum. The reason for adding it given by the London bakers is, that it renders the bread whiter, and enables them to separate readily the loaves from each other. This addition has been alleged by medical men, and is considered by the community at large, as injurious to the health, by occasioning constipation. But if we consider the small quantity of this salt added by the baker, not quite $5\frac{1}{2}$ grains to a quartern loaf, we will not readily admit these allegations. Suppose an individual to eat the seventh part of a quartern loaf a day, he would only swallow eight tenths of a grain of alum, or, in reality, not quite so much as half a grain; for one half of this salt consists of water. It seems absurd to suppose that half a grain of alum, swallowed at different times during the course of a day, should occasion constipation." Is it not more absurd to state $2\frac{1}{4}$ pounds or 36 ounces, as the alum adulteration of a sack of flour by the London bakers, and within a few periods to reduce that adulteration to one ounce?

That this voluntary abstraction of $\frac{35}{36}$ of the alum, and substitution of superior and more expensive flour, is not expected by him from the London bakers, is sufficiently evident from the following story. It would appear that one of his friends had invented a new yeast for fermenting dough, by mixing a quart of beer barm with a paste made of ten pounds of flour and two gallons of boiling water, and keeping this mixture warm for six or eight hours.

"Yeast made in this way," says he, "answers the purposes of the baker much better than brewers' yeast, because it is clearer, and free from the hop mixture which sometimes injures the yeast of the brewer. Some years ago the bakers of London, sensible of the superiority of this artificial yeast, invited a company of manufacturers from Glasgow to establish a manufactory of it in London, and promised to use no other. About 5,000*l*. accordingly was laid out on buildings and materials, and the manufactory was begun on a considerable scale. The ale-brewers, finding their yeast, for which they had drawn a good price, lie heavy on their hands, invited *all* the journeymen bakers to their cellars, gave them their full of ale, and promised to regale them in that manner every day, provided they would force their masters to take all their yeast from the ale-brewers. The journeymen accordingly declared, in a body, that they would work no more for their masters unless they gave up taking any more yeast from the manufactory. The masters were obliged to comply; the new manufactory was stopped, and the inhabitants of London were obliged to continue to eat worse bread, because it was the interest of the ale-brewers to sell the yeast. Such is the influence of journeymen bakers in the metropolis of England!"

This doleful diatribe seems rather extravagant; for surely beer yeast can derive nothing noxious to a porter drinking people, from a slight impregnation of hops; while it must form probably a more energetic ferment than the fermented paste of the new company, which at any rate could be prepared in six or eight hours by any baker who

ver his purpose of making a pleasant eating bread. But it is a very serious
ꞁ or gentleman of sedentary habits, or infirm constitution, to have their di-
ꞁ daily vitiated by damaged flour, whitened with 197 grains of alum per
  Acidity of stomach, indigestion, flatulence, headaches, palpitation, costive-
ury calculi may be the probable consequences of the habitual introduction
dulous and acescent matter.
  many experiments upon bread, and have found the proportion of alum very
quantity seems to be proportional to the badness of the flour; and hence
flour is used no alum need be introduced.   That alum is not necessary for
s utmost beauty, sponginess, and agreeableness of taste, is undoubted; since
d at a very extensive establishment in Glasgow, in which about 20 tons of
ularly converted into loaves in the course of a week, united every quality
with an absolute freedom from that acido-astringent drug.   Six pounds of
for every sack of flour; which, from its good quality, generally afforded
ern loaves of the legal weight of four pounds five ounces and a half each.
t nine ounces in the oven.
  ought to be able to analyze his flour. He may proceed as follows :—A duc-
be made with a pound of the flour and a sufficient quantity of water, and
ꞁ an hour; then having tied across a bowl a piece of silken sieve-stuff, a
ꞁ surface of the water in the bowl, the paste is to be laid upon the sieve on
:he water, and kneaded tenderly with the hand, so as merely to wash the
les out of it.   This portion of the flour gets immediately diffused through
ꞁe of the other constituents dissolve, and the gluten alone remains upon the
ꞁater must be several times renewed till it ceases to become milky.   The
of the gluten are made out of the sieve.
of the turbid washings are to be put into a tall conical glass or stoneware
owed to remain at rest, in a cool place, till they deposite the starch.   The
:ant liquor is then decanted off.   The deposite consists of starch, with a
  It must be washed till the water settles over it quite clear, and then it is

waters being evaporated at a boiling heat, discover flocks floating through
ꞁave been supposed by some to be albumen, and by others gluten.   At last,
ime precipitates.   When the residuum has assumed a sirupy consistence in
ꞁo be mixed with alcohol, in order to dissolve out its sugar.   Cold water
ꞁ what remains, effects a solution of the mucilage, and leaves the insoluble
ꞁr with the phosphate of lime.
le of analysis a minute portion of resin may remain in the gluten and in the
ꞁr; the gluten retains also a small proportion of a fixed oil, and a volatile
ch may be removed by alcohol.   If we wish to procure the resin alone, we
ꞁll treat the flour, well dried, with alcohol.
  flour, poor in gluten, is to be analyzed, the dough must be enclosed in a
ꞁaded with water, and washed in that state.
g barley-meal by the above process, hordeine, mixed with common starch, is
ꞁy may be separated by boiling water, which dissolves the starch, and leaves
ꞁnder the aspect of saw-dust.
  the plan of a London baker's oven, fired with coal fuel.
  the longitudinal section.
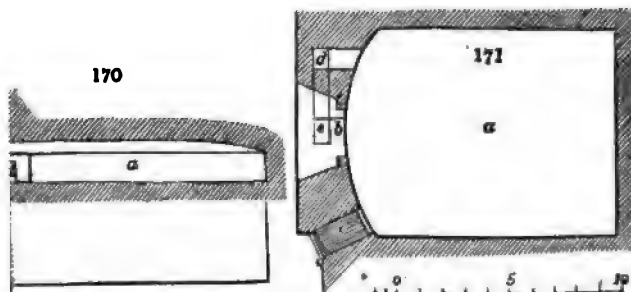
y of the oven; b, the door; c, the fire-grate and furnace; d, the smoke
lue above the door, to carry off the steam and hot air, when taking out the
:ess below the door, for receiving the dust; g, damper plate to shut off the
ꞁ, damper plate to shut off smoke flue, after the oven has come to its proper
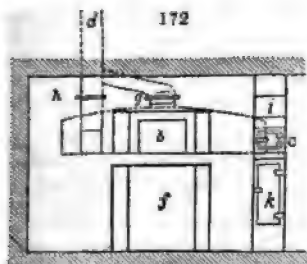
heat; *i*, a small iron pan over the fire-place *c*, for heating water; *k*, ash-pit below the furnace.

Fig. 172 is the front view; the same letters refer to the same objects in all the figures.

The flame and burnt air of the fire at *c*, sweep along the bottom of the oven by the right hand side, are reflected from the back to the left hand side, and thence escape by the flue *d ;* (see plan *fig.* 171.) Whenever the oven has acquired the proper degree of heat, the fire is withdrawn, the flues are closed by the damper plates, and the lumps of fermented dough are introduced.

BRECCIA, an Italian term, used by mineralogists and architects to designate such compound stony masses, natural or artificial, as consist of hard rocky fragments of considerable size, united by a common cement. When these masses are formed of small rounded pebbles, the conglomerate is called a pudding-stone, from a fancied resemblance to plum pudding.

Concrete, now so much used for the foundations of large buildings, is a factitious breccia, or pudding-stone. See CONCRETE.

BREWING. (*Brasser*, Fr.; *Brauen*, Germ.) The art of making beer, which see.

BRICK. (*Brique*, Fr.; *Backsteine, ziegelsteine*, Germ.) A solid, commonly rectangular, composed of clay, hardened by heat, and intended for building purposes. The natural mixture of clay and sand, called *loam*, as well as marl, which consists of lime and clay, with little or no sand, constitutes also a good material for making bricks. The poorer the marl is in lime, the worse adapted it is for agricultural purposes, and the better for the brick manufacturer, being less liable to fuse in his kiln. When a natural compound of silica and clay can be got nearly free from lime and magnesia, it forms a kind of bricks very refractory in the furnace, hence termed *fire-bricks*. Such a material is the slate-clay, *schieferthon*, of our coal measures, found abundantly, and of excellent quality, at Stourbridge, and in the neighborhood of Newcastle and Glasgow. The London brickmakers add to the clay about one third of coal ashes obtained from the kitchen dust-holes; so that when the bricks are put into the kiln, the quantity of coaly matter attached to their surface serves to economize fuel, and makes them less apt to shrink in the fire; though they are less compact, and probably less durable, than the bricks made in the coal districts of England.

The general process of brick-making consists in digging up the clay in autumn exposing it, during the whole winter, to the frost, and the action of the air, turning it repeatedly, and working it with the spade; breaking down the clay lumps in spring throwing them into shallow pits, to be watered and soaked for several days. The next step is to temper the clay, which is generally done by the treading of men or oxen. In the neighborhood of London, however, this process is performed in a horse-mill. The kneading of the clay is, in fact, the most laborious but indispensable part of the whole business; and that on which, in a great measure, the quality of the bricks depends. All the stones, particularly the ferruginous, calcareous, and pyritous kinds, should be removed, and the clay worked into a homogeneous paste, with as little water as possible.

The earth, being sufficiently kneaded, is brought to the bench of the moulder, who works the clay into a mould made of wood or iron, and strikes off the superfluous matter. The bricks are next delivered from the mould, and ranged on the ground; and when they have acquired sufficient firmness to bear handling, they are dressed with a knife, and stacked or built up in long dwarf walls, thatched over, and left to dry. An able workman will make, by hand, 5,000 bricks in a day.

The different kinds of bricks made in England are principally *place bricks, gray and red stocks, marl facing bricks*, and *cutting bricks*. The place bricks and stocks are used in common walling. The marls are made in the neighborhood of London, and used in the outside of buildings; they are very beautiful bricks, of a fine yellow color, hard, and well burnt, and, in every respect, superior to the stocks. The finest kind of marl and red bricks, called cutting bricks, are used in the arches over windows and doors, being rubbed to a centre, and gauged to a height.

In France attempts were long ago made to substitute animals and machines for the treading of men's feet in the clay-kneading-pit; but it was found that their schemes could not replace, with advantage, human labor, where it is so cheap, particularly for separating the stones and heterogeneous matters from the loam. The more it is worked, the denser, more uniform, and more durable, the bricks which are made of it. A good French workman, in a day's labor of 12 or 13 hours, it has been said, is able to mould from 9,000 to 10,000 bricks, 9 inches long, $4\frac{1}{2}$ inches broad, and $2\frac{1}{4}$ thick; but he must

have good assistants under him. In many brickworks near Paris, screw-presses are now used for consolidating the bricks and paving tiles in their moulds. M. Mollerat employed the hydraulic press for the purpose of condensing pulverized clay, which, after baking, formed beautiful bricks; but the process was too tedious and costly. An ingenious contrivance for moulding bricks mechanically, is said to be employed near Washington, in America. This machine moulds 30,000 in a day's work of 12 hours, with the help of one horse, yoked to a gin wheel, and the bricks are so dry when discharged from their moulds, as to be ready for immediate burning. The machine is described, with figures, in the *Bulletin de la Société d'Encouragement* for 1819, p. 361. *See further on, an account of our recent patents.*

Bricks, in this country, are generally baked either in a clamp or in a kiln. The latter is the preferable method, as less waste arises, less fuel is consumed, and the bricks are sooner burnt. The kiln is usually 13 feet long, by 10½ feet wide, and about 12 feet in height. The walls are one foot two inches thick, carried up a little out of the perpendicular, inclining towards each other at the top. The bricks are placed on flat arches, having holes left in them resembling lattice-work; the kiln is then covered with pieces of tiles and bricks, and some wood put in, to dry them with a gentle fire. This continues two or three days before they are ready for burning, which is known by the smoke turning from a darkish color to transparent. The mouth or mouths of the kiln are now dammed up with a *shinlog*, which consists of pieces of bricks piled one upon another, and closed with wet brick earth, leaving above it just room sufficient to receive a fagot. The fagots are made of furze, heath, brake, fern, &c., and the kiln is supplied with these until its arches look white, and the fire appears at the top; upon which the fire is slackened for an hour, and the kiln allowed gradually to cool. This heating and cooling is repeated until the bricks be thoroughly burnt, which is generally done in 48 hours. One of these kilns will hold about 20,000 bricks.

Clamps are also in common use. They are made of the bricks themselves, and generally of an oblong form. The foundation is laid with *place brick*, or the driest of those just made, and then the bricks to be burnt are built up, tier upon tier, as high as the clamp is meant to be, with two or three inches of breeze or cinders strewed between each layer of bricks, and the whole covered with a thick stratum of breeze. The fire-place is perpendicular, about three feet high, and generally placed at the west end; and the flues are formed by gathering or arching the bricks over, so as to leave a space between each of nearly a brick wide. The flues run straight through the clamp, and are filled with wood, coals, and breeze, pressed closely together. If the bricks are to be burnt off quickly, which may be done in 20 or 30 days, according as the weather may suit, the flues should be only at about six feet distance; but if there be no immediate hurry, they may be placed nine feet asunder, and the clamp left to burn off slowly.

Floating bricks are a very ancient invention: they are so light as to swim in water; and Pliny tells us, that they were made at Marseilles; at Colento, in Spain; and at Pittane, in Asia. This invention, however, was completely lost, until M. Fabbroni published a discovery of a method to imitate the floating bricks of the ancients. According to Posidonius, these bricks are made of a kind of argillaceous earth, which was employed to clean silver plate. But as it could not be our tripoli, which is too heavy to float in water, M. Fabbroni tried several experiments with mineral agaric, guhr, lac-lunæ, and fossil meal, which last was found to be the very substance of which he was in search. This earth is abundant in Tuscany, and is found near Casteldelpiano, in the territories of Sienna. According to the analysis of M. Fabbroni, it consists of 55 parts of silicious earth, 15 of magnesia, 14 of water, 12 of alumina, 3 of lime, and 1 of iron. It exhales an argillaceous odor, and, when sprinkled with water, throws out a light whitish-smoke. It is infusible in the fire; and, though it loses about an eighth part of its weight, its bulk is scarcely diminished. Bricks composed of this substance, either baked or unbaked, float in water; and a twentieth part of clay may be added to their composition without taking away their property of swimming. These bricks resist water, unite perfectly with lime, are subject to no alteration from heat or cold, and the baked differ from the unbaked only in the sonorous quality which they have acquired from the fire. Their strength is little inferior to that of common bricks, but much greater in proportion to their weight; for M. Fabbroni found, that a floating brick, measuring 7 inches in length, 4¼ in breadth, and one inch eight lines in thickness, weighed only 14¼ ounces; whereas a common brick weighed 5 pounds 6¾ ounces. The use of these bricks may be very important in the construction of powder magazines and reverberatory furnaces, as they are such bad conductors of heat, that one end may be made red hot while the other is held in the hand. They may also be employed for buildings that require to be light; such as cooking-places in ships, and floating batteries, the parapets of which would be proof against red-hot bullets.

The following plan of a furnace or kiln for burning tiles has been found very convenient :—

Fig. 173, front view, A A, B B, the solid walls of the furnace; *a a a*, openings to the ash-pit, and the draught hole; *b b b*, openings for the supply of fuel, furnished with a sheet-iron door. *Fig.* 174. Plan of the ash-pits and air channels c c c. The principal

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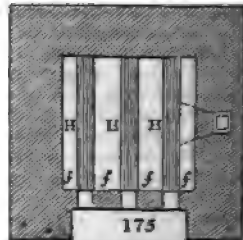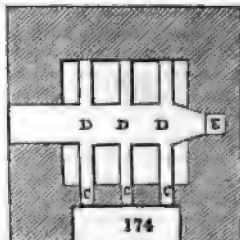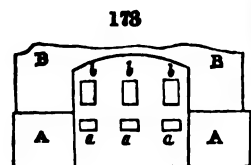
branch of the ash-pit D D D, is also the opening for taking out the tiles, after removing the grate; E the smoke flue. *Fig.* 175. Plan of the kiln seen from above. The grate H H H. The tiles to be fired are arranged upon the spaces *f f f f*.

Fig. 176 is the plan and section of one of the grates upon a much larger scale than in the preceding figures.

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Mechanical brick moulding.—Messrs. Lyne and Stainford obtained, in August, 1825, a patent for a machine for making a considerable number of bricks at one operation. It consists, in the first place, of a cylindrical pug-mill of the kind usually employed for comminuting clay for bricks and tiles, furnished with rotatory knives, or cutters, for breaking the lumps and mixing the clay with the other materials of which bricks are commonly made. Secondly, of two moveable moulds, in each of which fifteen bricks are made at once; these moulds being made to travel to and fro in the machine for the purpose of being alternately brought under the pug-mill to be fitted with the clay, and then removed to situations where plungers are enabled to act upon them. Thirdly, in a contrivance by which the plungers are made to descend, for the purpose of compressing the material and discharging it from the mould in the form of bricks. Fourthly, in the method of constructing and working trucks which carry the receiving boards, and conduct the bricks away as they are formed.

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Fig. 177 exhibits the general construction of the apparatus; both ends of which being exactly similar, little more than half of the machine is represented. *a* is the cylindrical pug-mill, shown partly in section, which is supplied with the clay and other materials from a hopper above; *b b*, are the rotatory knives or cutters, which are attached to the vertical shaft, and being placed obliquely, press the clay down toward the bottom of the cylinder, in the act of breaking and mixing it as the shaft revolves. The lower part of the cylinder is open; and immediately under it the mould is placed in which the bricks are to be formed. These moulds run to and fro upon ledges in the side frames of the machine; one of the moulds only can be shown by dots in the figure, the side rail intervening: they are situated at *c c*, and are formed of bars of iron crossing each other, and encompassed with a frame. The mould resembles an ordinary sash-window in its form, being divided into rectangular compartments (fifteen are proposed in each) of the dimensions of the intended bricks, but sufficiently deep to allow the material, after being considerably pressed in the mould, to leave it, when discharged, of the usual thickness of a common brick.

The mould being open at top and bottom, the material is allowed to pass into it, when situated exactly under the cylinder; and the lower side of the mould, when so placed, is to be closed by a flat board *d*, supported by the truck *e*, which is raised by a lever and roller beneath, running upon a plane rail with inclined ends.

The central shaft *f*, is kept in continual rotatory motion by the revolution of the upper horizontal wheel *g*, of which it is the axis; and this wheel may be turned by a horse yoked to a radiating arm, or by any other means. A part of the circumference of the wheel *g*, has teeth which are intended at certain periods of its revolution to take into a toothed pinion, fixed upon the top of a vertical shaft *h h*. At the lower part of this vertical shaft, there i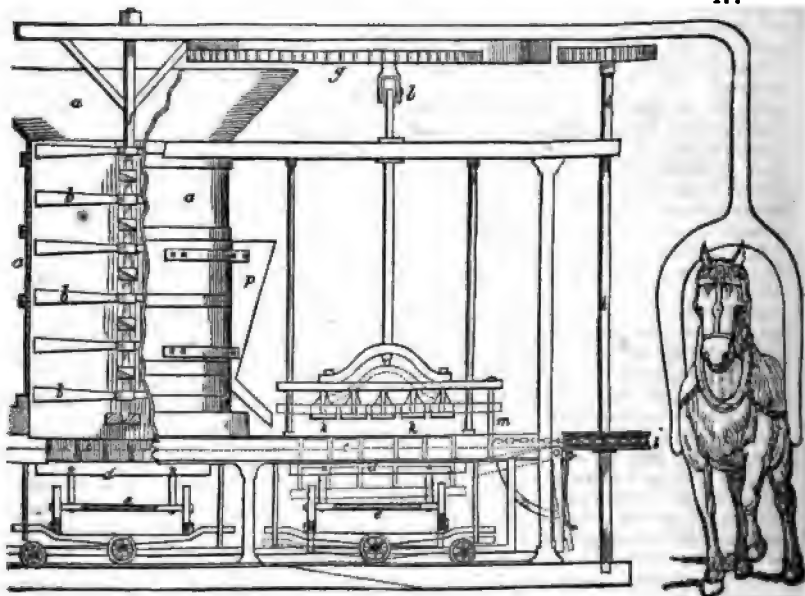s a pulley *i*, over which a chain is passed that is connected to the two moulds *c*, and to the frame in which the trucks are supported; by the rotation of the vertical shaft, the pulley winds a chain, and draws the moulds and truck-frames along.

The clay and other material having been forced down from the cylinder into the mould, the teeth of the horizontal wheel *g* now come into gear with the pinion upon *h*, and turn it and the shaft and pulley *i*, by which the chain is wound, and the mould at the right hand of the machine brought into the situation shown in the figure; a scraper or edge-bar under the pug-mill having levelled the upper face of the clay in the mould, and the board *d*, supported by the truck *e*, formed the flat under side.

The mould being brought into this position, it is now necessary to compress the materials, which is done by the descent of the plungers *k k*. A friction-roller *l*, pendent from the under side of the horizontal wheel as that wheel revolves, comes in contact with an inclined plane, at the top of the shaft of the plungers; and, as the friction-roller passes over this inclined plane, the plungers are made to descend into the mould, and to com- ⟍ press the material; the resistance of the board beneath causing the clay to be squeezed into a compact state. When this has been effectually accomplished, the further descent of the plungers brings a pin *m*, against the upper end of a quadrant catch-lever *n*, and, by depressing this quadrant, causes the balance-lever upon which the truck is now supported to rise at that end, and to allow the truck with the board *d* to descend, as shown by dots; the plungers at the same time forcing out the bricks from the moulds, whereby they are deposited upon the board *d*; when, by drawing the truck forward out of the machine, the board with the bricks may be removed, and replaced by another board. The truck may then be again introduced into the machine, ready to receive the next parcel of bricks.

By the time that the discharge of the bricks from this mould has been effected, the other mould under the pug-cylinder has become filled with the clay, when the teeth of the horizontal wheel coming round, take into a pinion upon the top of a vertical shaft exactly similar to that at *h*, but at the reverse end of the machine, and cause the moulds and the frame supporting the trucks to be slidden to the left end of the machine; the upper surface of the mould being scraped level in its progress, in the way already described. This movement brings the friction-wheel *o*, up the inclined plane, and thereby raises the truck with the board to the under side of the mould, ready to receive another supply of clay; and the mould at the left-hand side of the machine being now in its proper situation under the plungers, the clay becomes compressed, and the bricks discharged from the mould in the way described in the former instance; when this truck being drawn out, the bricks are removed to be dried and baked, and another board is placed in the same situation. There are boxes *p*, upon each side of the pug-cylinder containing sand, at the lower parts of which small sliders are to be opened (by contrivances not shown in the figure), as the mould passes under them, for the purpose of scattering sand upon the clay in the mould to prevent its adhering to the plungers. There is also a rack and toothed sector, with a balance-weight connected to the inclined plane at the top of the plunger-rods, for the purpose of raising the plunger after the

friction-roller has passed over it. And there is a spring acting against the back of the quadrant-catch for the purpose of throwing it into its former situation, after the pin of the plunger has risen.

One of the latest, and apparently most effective machines for brick-making, is that patented by Mr. Edward Jones, of Birmingham, in August, 1835. His improvements are described under four heads; the first applies to a machine for moulding the earth into bricks in a circular frame-plate horizontally, containing a series of moulds or rectangular boxes, standing radially round the circumference of the circular frame, into which boxes successively the clay is expressed from a stationary hopper as the frame revolves, and after being so formed, the bricks are successively pushed out of their boxes, each by a piston, acted upon by an inclined plane below. The second head of the specification describes a rectangular horizontal frame, having a series of moulding boxes placed in a straight range, which are acted upon for pressing the clay by a corresponding range of pistons fixed in a horizontal frame, worked up and down by rods extending from a rotatory crank shaft, the moulding boxes being allowed to rise for the purpose of enabling the pistons to force out the bricks when moulded, and leave them upon the bed or board below. The third head applies particularly to the making of tiles, for the flooring of kilns in which malt or grain is to be dried. There is in this contrivance a rectangular mould, with pointed pieces standing up for the purpose of producing air-holes through the tiles as they are moulded, which is done by pressing the clay into the moulds upon the points, and scraping off the superfluous matter at top by hand. The fourth or last head applies to moulding chimney pots in double moulds, which take to pieces for the purpose of withdrawing the pot when the edges of the slabs or sides are sufficiently brought into contact.

" The drawing which accompanies the specification very imperfectly represents some parts of the apparatus, and the description is still more defective; but as we are acquainted with the machinery, we will endeavor to give it an intelligible form, and quote those parts of the specification which point the particular features of novelty proposed to be claimed by the patentee as his invention, under the several heads." [*]
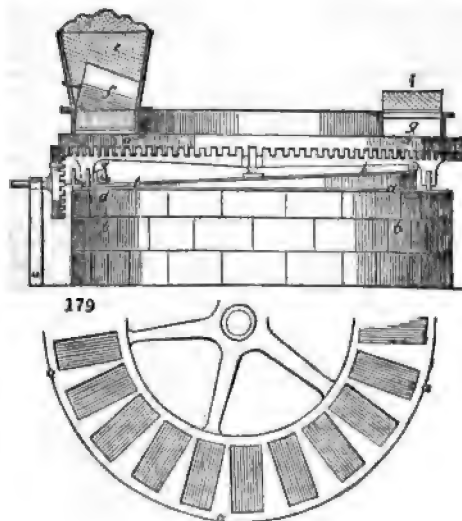
Fig. 178 represents, in elevation, the first-mentioned machine for moulding bricks. The moulds are formed in the face of a circular plate or wheel, $a\ a$, a portion of the upper surface of which is represented in the horizontal view, fig. 179. Any convenient number of these moulds are set radially in the wheel, which is mounted upon a central pivot, supported by the masonry $b\ b$. There is a rim of teeth round the outer edge of the wheel $a\ a$, which take into a pinion c, on a shaft connected to the first mover; and by these means the wheel a, with the moulding boxes, is made to revolve horizontally, guided by arms with anti-friction rollers, which run round a horizontal plate $a\ a$, fixed upon the masonry.

A hopper, e, filled with the brick earth shown with one of the moulding boxes in section, is fixed above the face of the wheel in such a way that the earth may descend from the hopper into the several moulding boxes as the wheel passes round under it; the earth being pressed into the moulds, and its surface scraped off smooth by a conical roller f, in the bottom of the hopper.

Through the bottom of each moulding box there is a hole for the passage of a piston rod g, the upper end of which rod carries a piston with a wooden pallet upon it, acting within the moulding box; and the lower end of this rod has a small anti-friction roller, which, as the wheel g revolves, runs round upon the face of an oblique ring or inclined way, $h\ h$, fixed upon the masonry.

The clay is introduced into the moulding boxes from the hopper, fixed over the lowest

* Mr. Newton, in his London Journal, February, 1837.

part of the inclined way h, and it will be perceived that as the wheel revolves, the piston rods g, in passing up the inclined way, will cause the pistons to force the new-moulded bricks, with their pallet or board under them, severally up the mould, into the situation shown at i, in *fig.* 178, from whence they are to be removed by hand. Fresh pallets being then placed upon the several pistons, they, with the moulds, will be ready for moulding fresh bricks, when, by the rotation of the wheel a, they are severally brought under the hopper, the pistons having sunk to the bottoms of their boxes, as the piston rods passed down the other side of the inclined way h.

The patentee says, after having described the first head of his invention, he would have it understood that the same may be varied without departing from the main object of the invention ; viz., that of arranging a series of moulds when worked by means of an inclined track, and in such manner that bricks, tiles, or other articles made of brick earth, may be capable of being formed in a mould with pallets or boards laid within the moulds, and constituting the bottom thereof, the bricks being removed from out of the moulds, with the pallets or boards under them, as above described. "I do not, therefore, confine myself to the precise arrangement of the machine here shown, though it is the best with which I am acquainted for the purpose."

The second head of the invention is another construction of apparatus for moulding bricks, in this instance, in a rectangular frame. *Fig.* 180 is a front elevation of the ma-

180   181
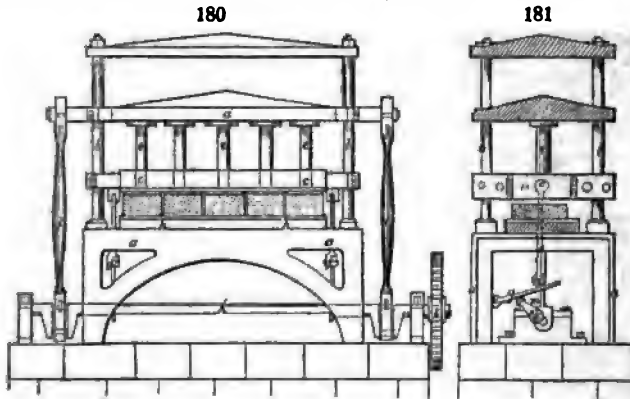
chine; *fig.* 181, a section of the same taken transversely. $a\,a$ is the standard frame-work and bed on which the bricks are to be moulded. Near the corners of this standard frame-work, four vertical pillars $b\,b$ are erected, upon which pillars the frame of the moulding boxes c, slides up and down, and also the bar d, carrying the rods of the pistons $e\,e\,e$. These pistons are for the purpose of compressing the clay in the moulding box, and therefore must stand exactly over and correspond with the respective moulds in the frame c beneath.

The sliding frame c, constituting the sides and ends of the moulding boxes, is supported at each end by an upright sliding rod f, which rods pass through guides fixed to the sides of the standard frame $a\,a$, and at the lower end of each there is a roller, bearing upon the levers g, on each side of the machine, but seen only in *fig.* 181, which levers, when depressed, allow the moulding boxes to descend, and rest upon the bed or table of the machine $h\,h$.

In this position of the machine resting upon the bed or table, the brick-earth is to be placed upon, and spread over, the top of the frame c, by the hands of workmen, when the descent of the plunger or pistons $e\,e\,e$, will cause the earth to be forced into the moulds, and the bricks to be formed therein. To effect this, rotatory power is to be applied to the toothed wheel i, fixed on the end of the main driving crank shaft $k\,k$, which on revolving will, by means of the crank rods $l\,l$, bring down the bar a, with the pistons or plungers $e\,e\,e$, and compress the earth compactly into the moulds, and thereby form the bricks.

When this has been done, the bricks are to be released from the moulds by the moulding frame c rising up from the bed, as shown in *fig.* 180, the pistons still remaining depressed, and bearing upon the upper surfaces of the bricks. The moulding frame is raised by means of cams m, upon the crank shaft, which at this part of the operation are brought under the levers g, for the purpose of raising the cams and the sliding rods f, into the position shown in *fig.* 181.

The bricks having been thus formed and released from their moulds, they are to be removed from the bed of the machine by pushing forward, on the front side, fresh boards

or pallets, which of course will drive the bricks out upon the other side, whence they are to be removed by hand.

There is to be a small hole in the centre of each pallet, and also in the bed, for the purpose of allowing any superfluous earth to be pressed through the moulding boxes when the pistons descend. And in order to cut off the projecting piece of clay which would be thus formed on the bottom of the brick, a knife-edge is in some way connected to the bed of the machine; and as the brick slides over it, the knife separates the protuberant lump : but the particular construction of this part of the apparatus is considered to be of little importance; and the manner of effecting the object is not clearly stated in the specification.

The patentee proposes a variation in this construction, which he describes in these words : " It will be evident that in place of having the moulds to rise, they may, by suitable arrangements, be made to descend below the bricks. In this case, in place of the boards, stationary blocks to receive the pallets must be fixed on the bed of the machine, and these blocks must be shaped in such a manner as to allow of the moulds passing over them ; and then it will be desirable to use the first part of my improvements, that of having the pallets within the moulds at the time of moulding the bricks; or in case of working with exceedingly stiff brick-earth, the pallets may be dispensed with." In 1835, 1,380,279,065 bricks paid duty in the United Kingdom; the revenue from which was 405,580l. 6s. 3d.

BRIMSTONE. (Soufre, Fr.; Schwefel, Germ.) Sulphur, which see.

BRITISH GUM. The trivial name given to starch, altered by a slight calcination in an oven, whereby it assumes the appearance and acquires the properties of gum, being soluble in cold water, and forming in that state a paste well adapted to thicken the colors of the calico printer. See STARCH.

BROMINE, one of the archæal elements, which being developed from its combinations at the positive pole of the voltaic circuit, has been therefore deemed to be idio-electropositive, like oxygen and chlorine. It derives its name from its nauseous smell, βρῶμη, fœtor. It occurs in various saline springs on the continent of Europe, in those of Ashby de la Zouche, and some others in England ; in the lake Asphaltites, in sponges, in some marine plants, in an ore of zinc, and in the cadmium of Silesia. At ordinary temperatures it is liquid, of a dark brown color in mass, but of a hyacinth-red in thin layers. Its smell is rank and disagreeable, somewhat like that of chlorine. It has a very caustic taste. Its specific gravity is 2·966. Applied to the skin it colors it deep yellow and corrodes it. One drop put within the bill of a bird suffices to kill it. It combines with oxygen with feeble affinity, forming bromic acid. Its attraction for hydrogen being far more energetic, it forms therewith a strong acid, the hydrobromic.

Bromine dissolves very sparingly in water, but it is very soluble in alcohol and ether. It combines with carbon, phosphorus, sulphur, and chlorine, as well as with most of the metals. From its scarcity it has not hitherto been applied to any purpose in the arts, but it is supposed to possess powerful discutient effects upon scrofulous and other glandular tumors, whence the waters containing it are prescribed as an internal and external remedy in such forms of disease.

BRONZE. A compound metal consisting of copper and tin, to which sometimes a little zinc and lead are added. This alloy is much harder than copper, and was employed by the ancients to make swords, hatchets, &c., before the method of working iron was generally understood. The art of casting bronze statues may be traced to the most remote antiquity, but it was first brought to a certain degree of refinement by Theodoros and Rœcus of Samos, about 700 years before the Christian era, to whom the invention of modelling is ascribed by Pliny. The ancients were well aware that by alloying copper with tin, a more fusible metal was obtained, that the process of casting was therefore rendered easier, and that the statue was harder and more durable; and yet they frequently made them of copper nearly pure, because they possessed no means of determining the proportions of their alloys, and because, by their mode of managing the fire, the copper became refined in the course of melting, as has happened to many founders in our own days. It was during the reign of Alexander that bronze statuary received its greatest extension, when the celebrated artist Lysippus succeeded by new processes of moulding and melting to multiply groups of statues to such a degree that Pliny called them the mob of Alexander. Soon afterwards enormous bronze colossuses were made, to the height of towers, of which the isle of Rhodes possessed no less than one hundred. The Roman consul Mutianus found 3,000 bronze statues at Athens, 3,000 at Rhodes, as many at Olympia and at Delphi, although a great number had been previously carried off from the last town.

In forming such statues, the alloy should be capable of flowing readily into all the parts of the mould, however minute ; it should be hard, in order to resist accidental blows, be proof against the influence of the weather, and be of such a nature as to acquire that greenish oxydized coat upon the surface which is so much admired in the

antique bronzes, called *patina antiqua*. The chemical composition of the bronze alloy is a matter therefore of the first moment. The brothers Keller, celebrated founders in the time of Louis XIV., whose *chefs d'œuvre* are well known, directed their attention toward this point, to which too little impoitance is attached at the present day. The statue of Desaix in the Place Dauphine, and the column in the Place Vendôme, are noted specimens of most defective workmanship from mismanagement of the alloys of which they are composed. On analyzing separately specimens taken from the bass-reliefs of the pedestal of this column, from the shaft, and from the capital, it was found that the first contained only six per cent. of alloy, and 94 of copper, the second much less, and the third only 0·21. It was therefore obvious that the founder, unskilful in the melting of bronze, had gone on progressively refining his alloy, by the oxydizement of the tin, till he had exhausted the copper, and that he had then worked up the refuse scoriæ in the upper part of the column. The cannons which the government furnished him for casting the monument consisted of—

Copper	-	-	-	89·360
Tin	-	-	-	10·040
Lead	-	-	-	0·102
Silver, zinc, iron, and loss				0·498
				100·000

The moulding of the several bass-reliefs was so ill executed, that the chisellers employed to repair the faults removed no less than 70 tons of bronze, which was given them, besides 300,000 francs for their work. The statues made by the Kellers at Versailles were found on chemical analysis to consist of—

	No. 1.	No. 2.	No. 3.	The mean.
Copper	91·30	91·68	91·22	91·40
Tin	1·00	2·32	1·78	1·70
Zinc	6·09	4·93	5·57	5·53
Lead	1·61	1·07	1·43	1·37
	100·00	100·00	100·00	100·00

The analysis of the bronze of the statue of Louis XV. was as follows :—

Copper	82·45	Its specific gravity was 8·482.
Zinc	10·30	
Tin	4·10	
Lead	3·15	
	100·00	

The alloy most proper for bronze medals which are to be afterward struck, is composed of from 8 to 12 parts of tin, and from 92 to 88 of copper ; to which if two or three parts in the hundred of zinc be added, they will make it assume a finer bronze tint. The alloy of the Kellers is famous for this effect. The medal should be subjected to three or four successive stamps of the press, and be softened between each blow by being heated and plunged into cold water.

The bronze of bells or bell metal is composed in 100 parts of copper 78, tin 22. This alloy has a fine compact grain, is very fusible and sonorous. The other metals sometimes added are rather prejudicial, and merely increase the profit of the founders. Some of the English bells consist of 80 copper, 10.1 tin, 5·6 zinc, and 4·3 lead ; the latter metal when in such large quantity is apt to cause insolated drops, hurtful to the uniformity of the alloy.

The *tam-tams and cymbals of bronze.*—The Chinese make use of bronze instruments forged by the hammer, which are very thin, and raised up in the middle ; they are called gongs, from the word *tshoung*, which signifies a bell. Klaproth has shown that they contain nothing but copper and tin ; in the proportions of 78 of the former metal and 22 of the latter. Their specific gravity is 8·815. This alloy when newly cast is as brittle as glass, but by being plunged at a cherry-red heat into cold water, and confined between two discs of iron to keep it in shape, it becomes tough and malleable. The cymbals consist of 80 parts copper and 20 tin.

Bronze vessels naturally brittle may be made tenacious by the same ingenious process, for which the world is indebted to M. Darcet. Bronze mortars for pounding have their brass tempered in the same way. Ancient warlike weapons of bronze were variously compounded ; swords were formed of 87½ copper, and 12½ tin in 100 parts ; the springs of knives consisted of 97 copper, and 3 tin.

Cannon *metal* consists of about 90 or 91 copper, and 10 or 9 of tin. From the experiments of Papacino-d'Antony, made at Turin, in 1770, it appears that the most proper

alloy for great guns is from 12 to 14 parts of tin to 100 of copper; but the Comte Lamartilliere concluded from his experiments made at Douay, in 1786, that never less than 8, nor more than 11 of tin should be employed in 100 parts of bronze.

Gilt ornaments of bronze.—This kind of bronze should be easy of fusion, and take perfectly the impression of the mould. The alloy of copper and zinc is when fused of a pasty consistence, does not make a sharp cast, is apt to absorb too much amalgam, is liable to crack in cooling, and is too tough or too soft for the chaser or the turner. Were the quantity of zinc increased to make the metal harder, it would lose the yellow color suitable to the gilder. A fourfold combination of copper, zinc, tin, and lead is preferable for making such ornamental bronze articles; and the following proportions are probably the best, as they unite closeness of grain with the other good qualities. Copper 82, zinc 18, tin 3 or 1, lead 1½ or 3. In the alloy which contains most lead, the tenacity is diminished and the density is increased, which is preferable for pieces of small dimensions. Another alloy, which is said to require for its gilding only two thirds of the ordinary quantity of gold, has the following composition : copper, 82·257; zinc, 17·481 ; tin, 0·238; lead, 0·024.

The antique bronze color is given to figures and other objects made from these alloys by the following process :—Two drachms of sal-ammoniac, and half a drachm of salt of sorrel (binoxalate of potash) are to be dissolved in fourteen ounce measures (English) of colorless vinegar. A hair pencil being dipped into this solution, and pressed gently between the fingers, is to be rubbed equally over the clean surface of the object, slightly warmed in the sun or at a stove; and the operation is to be repeated till the wished-for shade is obtained. (See GILDING.)

The bronze founder ought to melt his metals rapidly, in order to prevent the loss of tin, zinc, and lead, by their oxydizement. Reverberatory furnaces have been long used for this operation ; the best being of an elliptical form. The furnaces with dome tops are employed by the bell-founders, because their alloy being more fusible, they do not require so intense a heat ; but they also would find their advantage in using the most rapid mode of fusion. The surface of the melting metals should be covered with small charcoal, or coke; and when the zinc is added, it should be dexterously thrust to the bottom of the melted copper. Immediately after stirring the melted mass so as to incorporate its ingredients, it should be poured out into the moulds. In general, the metals most easily altered by the fire, as the tin, should be put in last. The cooling should be as quick as possible in the moulds, to prevent the risk of the metals separating from each other in the order of their density, as they are very apt to do. The addition of a little iron, in the form of tin-plate, to bronze, is reckoned to be advantageous.

One part of tin, and two parts of copper (nearly one atom of tin and four of copper, or more exactly, 100 parts of tin, and 215 copper), form the ordinary speculum metal of reflecting telescopes, which is of all the alloys the whitest, the most brilliant, the hardest, and the most brittle. The alloy of 1 part of tin, and 10 of copper (or nearly one atom of the former to eighteen of the latter), is the strongest of the whole series.

Ornamental objects of bronze, after being cast, are commonly laid upon red-hot coals till they take a dull red heat, and are then exposed for some time to the air. The surface is thereby freed from any greasy matter, some portion of the zinc is dissipated, the alloy assumes more of a coppery hue, which prepares for the subsequent gilding. The black tinge which it sometimes gets from the fire may be removed by washing it with a weak acid. It may be made very clean by acting upon it with nitric acid, of specific gravity 1·324, to which a little common salt and soot have been added, the latter being of doubtful utility; after which it must be well washed in water, and dried with rags or saw-dust.

BRONZING is the art of giving to objects of wood, plaster, &c., such a surface as makes them appear as if made of bronze. The term is sometimes extended to signify the production of a metallic appearance of any kind upon such objects. They ought first to be smeared over smoothly with a coat of size or oil varnish, and when nearly dry, the metallic powder made from Dutch foil, gold leaf, mosaic gold, or precipitated copper, is to be applied with a dusting bag, and then rubbed over the surface with a linen pad ; or the metallic powders may be mixed with the drying oil beforehand, and then applied with a brush. Sometimes fine copper, or brass filings, or mosaic gold, are mixed previously with some pulverized bone-ash, and then applied in either way. A mixture of these powders with mucilage of gum arabic is used to give paper or wood a bronze appearance. The surface must be afterward burnished. Copper powder precipitated by clean plates of iron, from a solution of nitrate of copper, after being well washed and dried, has been employed in this way, either alone or mixed with pulverized bone-ash. A finish is given to works of this nature by a coat of spirit varnish.

A white metallic appearance is given to plaster figures by rubbing over them an amalgam of equal parts of mercury, bismuth, and tin, and applying a coat of varnish over it. The iron-colored bronzing is given by black lead or plumbago, finely pulverized and

washed. Busts and other objects made of cast iron acquire a bronze aspect by being well cleaned and plunged in solution of sulphate of copper, whereby a thin film of this metal is left upon the iron.

Copper acquires by a certain treatment a reddish or yellowish hue, in consequence of a little oxyde being formed upon its surface. Coins and medals may be handsomely bronzed as follows; two parts of verdigris and 1 pa t of sal ammoniac are to be dissolved in vinegar; the solution is to be boiled, skimmed, and diluted with water till it has only a weak metallic taste, and upon further dilution lets fall no white precipitate. This solution is made to boil briskly, and is poured upon the objects to be bronzed, which are previously made quite clean, particularly free from grease, and set in another copper pan. This pan is to be put upon the fire, that the boiling may be renewed. The pieces under operation must be so laid that the solution has free access to every point of their surface. The copper hereby acquires an agreeable red-list brown hue, without losing its lustre. But if the process be too long continued, the coat of oxyde becomes thick, and makes the objects appear scaly and dull. Hence they must be inspected every 5 minutes, and be taken out of the solution the moment their color arrives at the desired shade. If the solution be too strong, the bronzing comes off with friction, or the copper gets covered with a white powder, which becomes green by exposure to air, and the labor is consequently lost. The bronzed pieces are to be washed with many repeated waters, and carefully dried, otherwise they would infallibly turn green. To give fresh made bronze objects an antique appearance, three quarters of an ounce of sal ammoniac, and a drachm and a half of binoxalate of potash (salt of sorrel) are to be dissolved in a quart of vinegar, and a soft rag or brush moistened with this solution is to be rubbed over the clean bright metal, till its surface becomes entirely dry by the friction. This process must be repeated several times to produce the full effect; and the object should be kept a litle warm. Copper acquires very readily a brown color by rubbing it with a solution of the common liver of sulphur, or sulphuret of potash.

The Chinese are said to bronze their copper vessels by taking 2 ounces of verdigris, 2 ounces of cinnabar, 5 ounces of sal ammoniac, and 5 ounces of alum, all in powder, making them into a paste with vinegar, and spreading this pretty thick like a pigment on the surfaces previously brightened. The piece is then to be held a litle while over a fire, till it becomes uniformly heated. It is next cooled, washed, and dried; after which it is treated in the same way once and again till the wished for color is obtained. An addition of sulphate of copper makes the color incline more to chestnut brown, and of borax more to yellow. It is obvious that the cinnabar produces a thin coat of sulphuret of copper upon the surface of the vessel, and might probably be used with advantage by itself.

To give the appearance of antique bronze to modern articles, we should dissolve 1 part of sal ammoniac, 3 parts of cream of tartar, and 6 parts of common salt in 12 parts of hot water, and mix with the solution 8 parts of a solution of nitrate of copper of specific gravity 1·160. This compound, when applied repeatedly in a moderately damp place to bronze, gives it in a short time a durable green coat, which becomes by degrees very beautiful. More salt gives it a yellowish tinge, less salt a blueish cast. A large addition of sal ammoniac accelerates the operation of the mordant.

Browning of gun-barrels and other arms.—By this process, the surface of several articles of iron acquires a shining brown color. This preparation, which protects the iron from rust, and also improves its appearance, is chiefly employed for the barrels of fowling-pieces and soldiers' rifles, to conceal the fire-arms from the game and the enemy. The finest kind of browning is the Damascus, in which dark and bright lines run through the brown ground.

This operation consists in producing a very thin uniform film of oxyde or rust upon the iron, and giving a gloss to its surface by rubbing wax over it, or coating it with a shellac varnish.

Several means may be employed to produce this rust speedily and well. The effect may be obtained by enclosing the barrels in a space filled with the vapor of muriatic acid. Moistening their surface with dilute muriatic or nitric acid, will answer the same purpose. But the most common material used for browning, is the butter or chloride of antimony, which, on account of its being subservient to this purpose, has been called bronzing salt. It is mixed uniformly with olive oil, and rubbed upon the iron slightly heated; which is afterwards exposed to the air, till the wished-for degree of browning is produced. A little aquafortis is rubbed on after the antimony, to quicken its operation. The brown barrel must be then carefully cleaned, washed with water, dried, and finally polished, either by the steel burnisher, or rubbed with white wax, or varnished with a solution of 2 ounces of shellac, and three drachms of dragon's blood, in 2 quarts of spirit of wine.

The following process may also be recommended: Make a solution with half an

ounce of aquafortis, half an ounce of sweet spirit of nitre, 1 ounce of spirit of wine, 2 ounces of sulphate of copper, and 1 ounce of tincture of iron, in so much water as will fill altogether a quart measure. The gun barrel to be browned must first of all be filed and polished bright, and then rubbed with unslaked lime and water to clear away all the grease. Its two ends must now be stopped with wooden rods, which may serve as handles, and the touch-hole must be filled with wax. The barrel is then to be rubbed with that solution, applied to linen rags or a sponge, till the whole surface be equally moistened; it is allowed to stand 24 hours, and is then scrubbed with a stiff brush. The application of the liquid and the brushing may be repeated twice or oftener, till the iron acquires a fine brown color. After the last brushing, the barrel must be washed with plenty of boiling water, containing a little potash; then washed with clean water, dried, rubbed with polishing hard wood, and coated with shellac varnish, for which purpose the barrel must be heated to the boiling point of water. It is finally polished with a piece of hard wood.

Storch recommends to make a browning solution with 1 part of sulphate of copper, one third of a part of sulphuric ether, and 4 parts of distilled water.

To give the damask appearance, the barrel must be rubbed over first with very dilute aquafortis and vinegar, mixed with a solution of blue vitriol; washed and dried, and rubbed with a hard brush to remove any scales of copper which may be precipitated upon it from the sulphate.

Statues, vases, bass-reliefs, and other objects made of gypsum, may be durably bronzed, and bear exposure to the weather better than after the ordinary oil-varnish, by the following process:—Prepare a soap from linseed oil, boiled with caustic soda ley, to which add a solution of common salt, and concentrate it by boiling. till it becomes somewhat granular upon the surface. It is then thrown upon a piece of linen cloth, and strained with moderate pressure. What passes through is to be diluted with boiling water, and again filtered. On the other hand, 4 parts of blue vitriol and 1 part of copperas are to be dissolved separately in hot water. This solution is to be poured slowly into the solution of soap, as long as it occasions any precipitate. This flocculent matter is a mixture of cupreous soap and ferruginous soap, that is, a combination of the oxydes of copper and iron with the margaric acid of the soda soap. The copper soap is green, the iron soap is reddish brown, and both together resemble that green rust which is characteristic of the antique bronzes. When the precipitate is completely separated, a fresh portion of the vitriol solution is to be poured upon it in a copper pan, and is made to boil, in order to wash it. After some time, the liquid part must be decanted, and replaced by warm water for the purpose of washing the metallic soaps. They are finally treated with cold water, pressed in a linen bag, drained, and dried. In this state the compound is ready for use in the following way :—

Three pounds of pure linseed oil are to be boiled with twelve ounces of finely-powdered litharge, then strained through a coarse canvass cloth, and allowed to stand in a warm place till the soap turns clear. Fifteen ounces of this soap varnish, mixed with 12 ounces of the above metallic soaps, and 5 ounces of fine white wax, are to be melted together at a gentle heat in a porcelain basin, by means of a water bath. The mixture must be kept for some time in a melted state, to expel any moisture which it may contain. It must be then applied, by means of a painter's brush, to the surface of the gypsum previously heated to the temperature of about 200° F. By skilful management of the heat, the color may be evenly and smoothly laid on without filling up the minute lineaments of the busts. When, after remaining in the cool air for a few days, the smell of the pigment has gone off, the surface is to be rubbed with cotton wool, or a fine linen rag, and variegated with a few streaks of metal powder or shell gold. Small objects may be dipped in the melted mixture, and then exposed to the heat of a fire till they are thoroughly penetrated and evenly coated with it.

BROWN DYE. Upon this subject some general views are given in the article Dyeing, explanatory of the nature of this color, to which I may in the first place refer. This dye presents a vast variety of tints, from yellow and red to black brown, and is produced either by mixtures of red, yellow, and blue with each other, or of yellow or red with black, or by substantive colors, such as catechu or oxyde of manganese, alone. We shall here notice only the principal shades; leaving their modifications to the caprice or skill of the dyer.

1. Brown from mixture of other colors.

Wool and woollen cloths must be boiled with one eighth their weight of alum and sulpho-tartrate of iron (see this article); afterwards washed, and winced through the madder bath, which dyes the portion of the stuff imbued with the alum red, and that with the salt of iron black; the tint depending upon the proportion of each, and the duration of the madder bath.

A similar brown is produced by boiling every pound of the stuff with two ounces of alum, and one ounce of common salt, and then dyeing it in a bath of logwood contain-

ing either sulphotartrate, acetate, or sulphate of iron. Or the stuff may be boiled with alum and tartar, dyed up in a madder bath, and then run through a black bath of iron mordant and galls or sumach. Here the black tint is added to the red till the proper hue be hit. The brown may be produced also by adding some iron liquor to the madder bath, after the stuff has been dyed up in it with alum and tartar. A better brown of this kind is obtained by boiling every pound of wool with 2 ounces of alum. dyeing it up in cochineal, then changing the crimson thus given into brown, by turning the stuff through the bath after acetate of iron has been added to it. Instead of the cochineal, archil, or cutbear, with a little galls or sumach, may be used.

Wool or silk may also receive a light blue ground from the indigo vat, then be mordanted with alum, washed, and turned through a madder bath till the wished-for brown be brought out. For the deeper shades, galls or sumach may be added to the paler Brazil-wood, with more or less iron mordant. Instead of the indigo vat, Saxon blue may be employed to ground the stuff before dyeing it with madder, or 5 pounds of madder, with 1 pound of alum, a solution of one tenth of a pound of indigo in sulphuric acid, may be used with the proper quantity of water for 20 pounds of wool; for dark shades, some iron mordant may be added. Or we may combine a bath of cochineal or cutbear, fustic, and galls, and add to it sulphate of iron and sulphate of indigo, blunted with a little potash.

If we boil woollen cloth with alum and tartar, then pass it through a madder bath, and afterward through one of weld or fustic, containing more or less iron mordant, we obtain shades variable, according to the proportions of the materials, from *mordoré* and cinnamon to chestnut brown.

After the same manner, bronze colors may be obtained from the union of olive dyes with red. For 25 pounds of cloth, we take 4 pounds of fustic chips, boil them for 2 hours, turn the cloth in this bath for an hour, and drain it; then add to the bath from 4 to 6 ounces of sulphate of iron, and 1 pound of ordinary madder, or 2 pounds of sandal-wood; put the cloth again in this compound bath, and turn it through, till the desired shade be obtained. By changing the proportions, and adding an iron mordant, other tints may be produced.

This mode of dyeing is suitable for silk, but with three different baths; one of logwood, one of Brazil-wood, and one of fustic. The silk, after being boiled with soap, is to be alumed, and then dyed up in a bath compounded of these three decoctions, mixed in the requisite proportions. By the addition of walnut peels, sulphate of copper, and a little sulphate of iron, or by passing the silk through a bath of annotto, a variety of brown shades may be had.

Or the silk may receive an annotto ground, and then be passed through a bath of logwood or Brazil-wood. For 10 pounds of silk, 6 ounces of annotto are to be taken, and dissolved with 18 ounces of potashes in boiling water. The silk must be winced through this solution for 2 hours, then wrung out, dried, next alumed, passed through a bath of Brazil-wood, and finally through a bath of logwood, containing some sulphate of iron. It is to be wrung out and dried.

Brown of different shades is imparted to cotton and linen, by impregnating them with a mixed mordant of acetates of alumina and iron, and then dyeing them up, either with madder alone, or with madder and fustic. When the aluminous mordant predominates, the madder gives an amaranth tint. For horse-chestnut brown, the cotton must be galled, plunged into a black bath, then into a bath of sulphate of copper, next dyed up in a decoction of fustic, wrung out, passed through a strong madder bath, then through the sulphate of copper solution, and finished with a soap boil. Different shades of cinnamon are obtained, when cottons first dyed up with madder get an olive cast with iron liquor in a fustic bath.

These cinnamon and mordoré shades are also produced by dyeing them first in a bath of weld and verdigris, passing them through a solution of sulphate of iron, wringing and drying them; next putting them through a bath containing 1 pound of galls for 10 pounds of stuff, again drying, next aluming, and maddering. They must be brightened by a boil in soap water.

A superior brown is produced by like means upon cotton goods, which have undergone the oiling process of the Turkey red dye. Such stuffs must be galled, mordanted with alum (see MADDER), sulphate of iron, and acetate of lead (equal to ⅔ of the alum); after washing and drying, dyed in a madder bath, and cleared with a soap boil. The tint of brown varies with the proportion of alum and sulphate of iron.

We perceive from these examples, in how many ways the browning of dyes may be modified, upon what principles they are founded, and how we have it in our power to turn the shade more or less toward red, black, yellow, blue, &c.

Brown may be produced by direct dyes. The decoction of oak bark dyes wool a fast brown of different shades, according to the concentration of the bath. The color is more lively with the addition of alum.

The decoction of bastard marjoram (*Origanum vulgare*) dyes cotton and linen a reddish brown, with acetate of alumina. Wool takes from it a dark brown.

The bark of the mangrove tree (*Rizophora mangle*) affords to wool boiled with alum and tartar a fine red brown color, which, with the addition of sulphate of iron, passes into a fast chocolate.

The *Bablah*, the pods of the East Indian *Mimosa cineraria*, and the African *Mimosa nilotica*, gives cotton a brown with acetate or sulphate of copper.

The root of the white sea rose (*Nymphæa alba*) gives to cotton and wool beautiful shades of brown. A mordant of sulphate of iron and zinc is first given, and then the wool is turned through the decoction of the root, till the wished-for shade is obtained. The cotton must be mordanted with a mixture of the acetates of iron and zinc.

Walnut peels (*Juglans regia*), when ripe, contain a dark brown dye stuff, which communicates a permanent color to wool. The older the infusion or decoction of the peel, the better dye does it make. The stuff is dyed in the lukewarm bath, and needs no mordant, though it becomes brighter with alum. Or this dye may be combined with the madder or fustic bath, to give varieties of shade. For dyeing silk, this bath should be hardly lukewarm, for fear of causing inequality of color.

The peelings of horse-chestnuts may be used for the same purpose. With muriate of tin they give a bronze color, and with acetate of lead a reddish brown.

Catechu gives cotton a permanent brown dye, as also a bronze, and mordoré, when its solution in hot water is combined with acetate or sulphate of copper, or when the stuff is previously mordanted with the acetates of copper and alumina mixed, sometimes with a little iron liquor, rinsed, dried, and dyed up, the bath being at a boiling heat.

Ferrocyanate of copper gives a yellow brown or a bronze to cotton and silk.

The brown color called *carmelite* by the French is produced by one pound of catechu to four ounces of verdigris, with five ounces of muriate of ammonia. The bronze (*solitaire*) is given by passing the stuff through a solution of muriate or sulphate of manganese, with a little tartaric acid, drying, passing through a potash ley at 4° Baumé, brightening and fixing with solution of chloride of lime.

BRUSHES. (*Brosses*, Fr.; *Bürsten*, Germ.) Mr. T. Mason obtained a patent in October, 1830, for an improvement in the manufacture of this article. It consists in a firmer mode of fixing the knots or small bundles of hair into the stock or the handle of the brush. This is done by forming grooves in the stocks of the brushes, for the purpose of receiving the ends of the knots of hair, instead of the holes drilled into the wood, as in brushes of the common constructions. These grooves are to be formed like a dovetail, or wider at the bottom than the top; and when the ends of the knots of hair have been dipped into cement, they are to be placed in the grooves and compressed into an oval form, by which the ends of the hair will be pressed outwards into the recess or wider part of the dovetailed groove, or the grooves may be formed with threads or teeth on the sides, instead of being dovetailed; and the cement and hairs being pressed into the teeth or threads, will cause them to adhere firmly to the stock or handle of the brush.

A metal ferrule may be placed on the outside of the stock of the brush, if necessary, and secured by pins or rivets, or in any other convenient manner, which ferrule may also form one side of the outer groove. *Fig.* 182 is a plan view of the stock of a round brush; *fig.* 183 is a section of the same; *a a* are the dovetailed grooves, which are turned out of the wood; *b* is the metal ferrule; *c c* are knots or small bundles of hair, to form the brush. After a number of the knots of hair are prepared, the ends are to be dipped into proper cement, and then placed into the grooves, when their ends are to be squeezed by a pair of pliers, or other means, which will compress them into the oval shape, as shown in *fig.* 184, and cause the ends of the hairs to extend outward under the dovetailed part of the recess.

The knots of hair are to be successively placed in the grooves, and forced up by a tool against the last knot put in, and so on, until the grooves are filled; *fig.* 184 is a section taken through a brush with teeth or threads of a screw formed upon the sides of the groove; into these teeth or threads the cement and hairs will be forced by the compression, by which means they will be held firmly in the stock of the brush.

BUTTER. (*Beurre*, Fr.; *Butter*, Germ.) Milk contains a fatty matter of more or less consistency, modified very much according to the nature of the animals which afford it. This substance is butter, held suspended in the milk by means of the caseous matter and whey, with which it is intimately blended. Milk is a true emulsion resulting from the mixture of these three ingredients, owing its opacity and white color to the diffusion through it of that butyraceous oil. When any circumstance
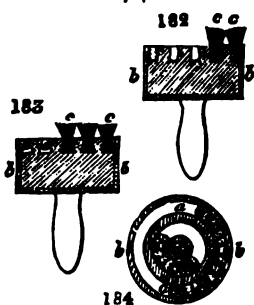
dissolves this union, each component becomes insulated, and manifests its peculiar properties. Milk, even left to itself, at a temperature of from 50° to 60° F., separates spontaneously into several products. A layer of a fatter, more consistent, but lighter nature, floats upon its surface, while the subjacent liquid forms a white magma, which retains among its curdy flocks all the whey of the milk. The upper layer or cream contains nearly the whole of the butter; but a portion remains entangled with the curd and whey below.

It belongs to a work on husbandry or rural economy to treat fully of the operations of the dairy; one of the principal of which is the extraction of butter from milk.

The Tartars and French have been long in the habit of preserving butter, by melting it with a moderate heat, whereby are coagulated the albuminous and curdy matters remaining in it, which are very putrescible. This fusion should be made by a heat of a water bath, about 176° F., continued for some time, to effect the more complete purification of the butter. If in this settled liquefied state it be carefully decanted, strained through a tammy cloth, and slightly salted, it may be kept for a long time nearly fresh, without becoming in any degree rancid, more especially if it be put up in small jars closely covered.

BUTTER OF CACAO. See CACAO and OILS.

BUTTON MANUFACTURE. This art is divided into several branches, constituting so many distinct trades. Horn, leather, bone, and wood, are the substances frequently employed for buttons, which are either plain, or covered with silk, mohair, thread, or other ornamental materials. The most durable and ornamental buttons are made of various metals, polished, or covered with an exceedingly thin wash, as it is termed, of some more valuable metal, chiefly tin, silver, and gold.

Those buttons intended to be covered with silk, &c. are termed, in general, moulds. They are small circles, perforated in the centre, and made from those refuse chips of bone which are too small for other purposes. These chips, which, for the large and coarser buttons, are pieces of hard wood, are sawn into thin flakes, of an equal thickness; from which, by a machine, the button moulds are cut out at two operations.

The shavings, sawdust, and more minute fragments, are used by manufacturers of cutlery and iron toys, in the operations of case-hardening; so that not the smallest waste takes place.

Metal buttons are formed of an inferior kind of brass, pewter, and other metallic compositions: the shanks are made of brass or iron wire, the formation of which is a distinct trade. The buttons are made by casting them round the shank. For this purpose the workman has a pattern of metal, consisting of a great number of circular buttons, connected together in one plane by very small bars from one to the next; and the pattern contains from four to twelve dozen of buttons of the same size. An impression from this pattern is taken in sand in the usual manner; and shanks are pressed into the sand in the centre of each impression, the part which is to enter the metal being left projecting above the surface of the sand. The buttons are now cast from a mixture of brass and tin; sometimes a small proportion of zinc is added, which is found useful in causing the metal to flow freely into the mould, and make a sharp casting. When the buttons are cast, they are cleaned from the sand by brushing; they are then broken asunder, and carried to a second workman at the lathe, who inserts the shank of a button into a chuck of a proper figure, in which it is retained by the back centre of the lathe being pressed against the button with a spring. The circumference is now, by filing it as it turns round, reduced to a true circle; and the button is instantly released by the workman's holding back the centre, and is replaced by another. A third workman now turns the back of the button smooth, in a chuck lathe, and makes the projecting part round the shank true; and a fourth renders the face of the button smooth, by placing it in a chuck, and applying the edge of a square bar of steel across its centre.

Gilt buttons are stamped out from copper, (having sometimes a small alloy of zinc,) laminated in the flatting mill to the proper thickness. The stamp is urged by a fly-press, which cuts them out at one stroke. These circular pieces, called blanks, are annealed in a furnace to soften them; and the maker's name, &c. is struck on the back by a monkey, which is a machine very similar to a pile-engine. This stamp also renders the face very slightly convex, that the buttons may not stick together in the gilding process. The shanks are next soldered on. The burnishing is performed by a piece of hæmatites or blood-stone, fixed into a handle, and applied to the button as it revolves by the motion of the lathe.

A great number of the buttons, thus prepared for gilding, are put into an earthen pan, with the proper quantity of gold to cover them,* amalgamated with mercury in the fol-

* By act of parliament 5 grains of gold are allotted for the purpose of gilding 144 buttons, though they may be tolerably well gilt by half that quantity. In this last case, the thickness would be about the 214,000th part of an inch.

lowing manner :— The gold is put into an iron ladle, and a small quantity of mercury added to it; the ladle is held over the fire, till the gold and mercury are perfectly united. This amalgam being put into the pan with the buttons, as much aquafortis, diluted with water, as will wet them all over, is thrown in, and they are stirred up with a brush, till the acid, by its affinity to the copper, carries the amalgam to every part of its surface, covering it with the appearance of silver. When this is perfected, the acid is washed away with clean water. This process by the workman is called quicking.

The old process in gilding buttons, called the drying off, was exceedingly pernicious to the operator, as he inhaled the vapor of the mercury, which is well known to be a violent poison. In order to obviate this, the following plan of apparatus has been employed with success. The vapor, as it rises from the pan of buttons heated by a charcoal fire, is conducted into an oblong iron flue or gallery, gently sloped downwards, having at its end a small vertical tube dipping into a water cistern, for condensing the mercury, and a large vertical pipe for promoting the draught of the products of the combustion.

Plated buttons are stamped by the fly-press, out of copper-plate, covered on one side with silver at the flatting-mill. The copper side is placed upwards in stamping, and the die or hole through which they are stamped is rather chamfered at its edge, to make the silver turn over the edge of the button. The backs are stamped in the same manner as the gilt buttons. The shanks are soldered on with silver solder, and heated one by one in the flame of a lamp, with a blow-pipe urged by bellows. The edges are now filed smooth in the lathe, care being taken not to remove any of the silver which is turned over the edge. They are next dipped in acid, to clean the backs, and boiled in cream of tartar and silver, to whiten them; after which they are burnished, the backs being first brushed clean by a brush held against them as they revolve in the lathe. The mode of burnishing is the same as for gilt buttons.

Button shanks are made by hand from brass or iron wire, bent and cut by the following means :—

The wire is lapped spirally round a piece of steel bar. The steel is turned round by screwing it into the end of the spindle of a lathe, and the wire by this means lapped close round it till it is covered. The coil of wire thus formed is slipped off, and a wire fork or staple with parallel legs put into it. It is now laid upon an anvil, and by a punch the coil of wire is struck down between the two prongs of the fork, so as to form a figure 8, a little open in the middle. The punch has an edge which marks the middle of the 8, and the coil being cut open by a pair of shears along this mark, divides each turn of the coil into two perfect button shanks or eyes.
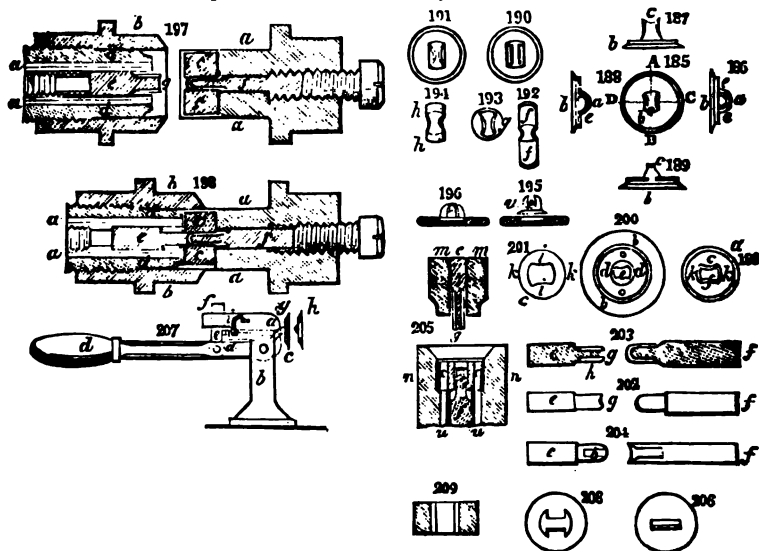
Mr. Holmes, of Birmingham, obtained in May, 1833, a patent for an improved construction of buttons. *Fig.* 185 represents the outside appearance of one of his improved shanks, as raised or formed out of the disc of metal which is to constitute the

back of the button ; *fig.* 186 an edge view, looking through the shank or loop; *fig.* 187 is another edge view, looking at the raised shank or loop endways; *fig.* 188 is a section taken through the shank and disc in the direction of the dotted line A B, in *fig.* 185 ; and *fig.* 189 another section taken in the direction of the dotted line C D, in *fig.* 185. All these figures of his improved shanks, as well as those hereinafter described, together with the tools used to form the same, are drawn at about half the real size, to show the parts more distinctly. It will be seen that the shanks or loops *a a* are formed by partially cutting and raising, or forcing up a portion of the metal disc or back *b*, and are compressed or formed by the action of the tools, or punches and dies, so as to have a rounded figure on the inside of the top part of the shank, as at *c*, the edges of the metal being turned so as to prevent them cutting the threads by which the button is fastened to the cloth or garment. It will be observed that, there being but one passage or way through which the thread can be passed to sew on the button, and that opening being rounded on all edges, will cause the threads to keep in the centre of the shanks, the form of the shank allowing a much neater attachment to the garment, and keeping the threads from the edges of the metal. The ends of the shank, or portions *e e*, which rise up from the disc or back *b*, are made nearly circular, in order to avoid presenting any edges of the metal to the sides of the button hole; and when the shank is sewed on the cloth, it forms, in conjunction with the threads, a round attachment, thereby preventing the shank from cutting or wearing the button-hole; the threads, when the shank is properly sewed to the garment, nearly filling up the opening through the shank, and completing that portion of the circle which has been taken out of the shank by the dies in forming the crescented parts of the loop. It will be therefore understood that the intention is, that the inside edges of the shank should be turned as much as possible away from the threads by which the button is sewed on the cloth, and that the outside of the shank should be formed so as to present rounded surfaces to the button-hole, and that the thread should fill up the opening through the shank, so as to produce a round attachment to the garment. It should here be observed, that the backs of the buttons shown in these figures are of the shape generally used for buttons covered with Florentine or other fabric, or faced with plates of thin metal, and are intended to have the edges of a disc, or what is termed a shell, forming the face, to be closed in upon the inclined or bevelled edges of the backs. Having now described the peculiar form of the improved shanks which he prefers, for buttons to be covered with Florentine or other fabric, or shells of thin metal plate, he proceeds to describe some of the different variations from the same.

Fig. 190 is a representation of a shank, the cut through the disc or back being effected by a parallel rib on the die, and corresponding groove in the shaping punch, instead of the semicircular or crescented cut shown in *fig.* 185 ; *fig.* 191 is a view of another shank, the separation of the sides of the loop being performed by straight edges in both punch and die. He prefers finishing this shaped shank (that is, giving it the rounded form, to prevent its cutting the threads) by detached punches, and dies, or pincers, as will be hereinafter described. *Fig.* 192 is a representation of one of the improved shanks, which has merely portions, *f f*, of the back of the button connected to its ends. This shank may be used for buttons which have a metal shell to be closed in upon the bevelled edges of the ends, or the shank piece may be otherwise connected to the face part of the button. *Fig.* 193 is a representation of a shank raised out of a small disc of metal *g g*, intended to be soldered to the disc of metal forming the button, or it may be otherwise fixed to the back; *fig.* 194 is a representation of another shank for the same purpose, having only portions of metal *h h*, for soldering or otherwise attaching it to the back of the button, as by placing a ring or annular piece over it forming the back, which shall be confined to the face as before described ; *fig.* 195 is a representation of a shank raised upon a dish or bevelled piece of metal, and is intended to be used for buttons made from pearl-shell, horn, wood, paper, or other substances. The back part of the button has a dovetailed recess formed in it to receive the dish-shaped back, which is pressed into the recess, the edges of the dish being expanded in the dovetailed parts of the recess by the ordinary means, and thereby firmly fixing it to the button, as shown in *fig.* 196.

Having now explained the peculiar forms of his improved shanks, he proceeds to describe the tools, or punches and dies, by which he cuts the disc or back from out of a sheet of metal, and at the same operation produces and forms the shank complete. *Fig.* 197 is a longitudinal section taken through a pair of dies and punches when separated ; *fig.* 198 is a similar section, taken when they are put together, and in the act of forming a shank after cutting out the disc or back of the button from a sheet of metal ; *fig.* 199 is a face view of the punch ; and *fig.* 200 is a similar representation of the counter die, with the tools complete ; *a* is the punch or cutter, and *b* the counter bed, by the circular edges of which the disc of metal is cut out of the sheet ; *c* is a die, fixed in the cutter *a* (upon which the name of the button-maker may be engraved). *Fig.* 201 is a face view of this die when removed out of the punch; *d* is the counter die to the die *c*. It will be perceived that these dies *c* and *d*, together with the punch and bed, compress the disc of metal into the form re-
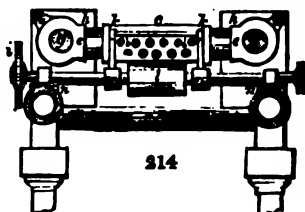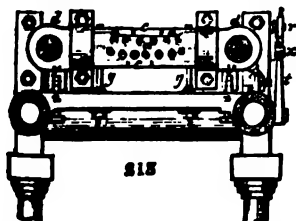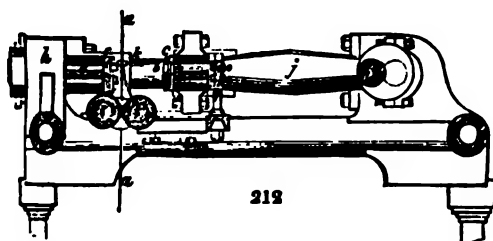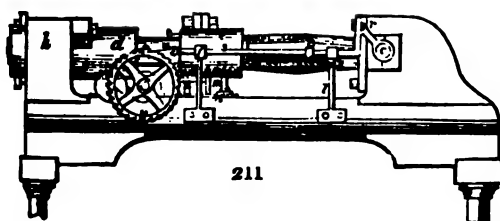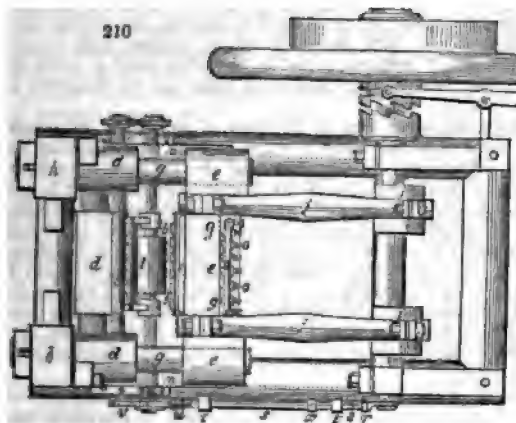
quired for the back of the button; that shown in the figures, as before stated, is of the shape used for buttons to be covered with Florentine or thin plate metal, in a round shell closed in upon the inclined or bevelled edge of the back; *e* is the cutting and shaping punch of the shank, which is fixed within the counter die; this punch cuts through the metal of the disc, and forms the shank as the dies approach nearer together, by raising or forcing it up into the recess or opening in the die *c*, where it is met by the end of another shaping punch *f*, fixed in the punch *a*, which compresses the upper part of the shank into the recess *g*, in the end of the punch *e*, thereby giving the shank its rounded figure, and at the same time forming the other part of the shank into the required shape, as described at *figs.* 185 to 189. The ends of these shaping punches fit into and over each other, as will be seen by the detached figures of the punches designed for forming the shank first described. *Fig.* 202 is a representation of the punches when apart and removed out of the dies; *fig.* 203 is a longitudinal section of the same; *fig.* 204 is another view of the punches as seen on the top. The sharp edge of the recess *h*, in the punch *e*, comes in contact with the cutting edges of the projecting rib *i* of the die *c*, and thereby cuts through so much of the metal as is required. The edge *k* of this die keeps the outside ends of the shank of a spherical figure, as before explained, while the punches force up the metal, and form the elevated loop or shank : *u u* are holes made through the counter die *d*, for the passage of clearing pins, which force out the shank or back piece from the counter die when finished; the operation of which will be shown when describing the machinery hereafter. There are adjusting screws at the back of the punches and dies, by which they can be regulated and brought to their proper position one to the other.

Although he has shown the punches which form his improved shanks, fixed into and working in conjunction with the punch and dies which cut out and shape the discs of metal for the back of the button, yet he does not intend to confine himself to that mode of using them, as flat blanks or discs for the backs of buttons may be cut out in a separate stamping press, and afterwards shaped in the same press or in another, and then brought under the operation of the punches which form his improved shanks, fixed in any suitable press. This last mentioned mode of producing button shanks and backs he prefers when such metals are employed as require annealing between the operations of shaping the backs and forming the shank. *Fig.* 205 is a section taken through a pair of dies, in which the operation only of forming the shank is to be performed, the backs being previously shaped in another press. In this instance the punches *e* and *f* are mounted in guide-pieces *m* and *n*, which keep them in the proper position towards each other, the die *c* being mounted in the piece *n*, and acting against the face of the guide *m*. The blanks or backs of the buttons may be fed into these dies by hand or any other means; and after the shank is formed, the finished back can be pushed out of the lower die by clearing rods passed through the holes *u u* and removed by hand, or in any convenient manner.

When his improved shanks are formed out of iron or other metal which is too brittle to allow of the shank being forced up and finished at one operation in the dies and punches, he prefers cutting out and shaping the blank or back of the button first, and after annealing it, to raise or force up the portion of metal to form the shank into the shape shown in *fig.* 206, that is, without the edges of the metal being turned to prevent their cutting the threads, and after again annealing it, to bend or turn the edges into the shape shown in *fig.* 191 by means of suitable punches in another press, or by a pair of pincers and punch as shown in *fig.* 207, which is a side view of a small apparatus to be used for turning the edges of the shank by hand, with a partly formed shank seen under operation. *a*, is the upper jaw of a pair of pincers, this jaw being fixed on to the head of the standard *b;* the under jaw *c*, is formed by the end of the lever or handle *d*, which has its fulcrum in the standard *b*. *e* is a small punch, passed through a guide hole in the head of the standard, one end projecting into the jaws of the pincers, the other against a piece *f*, attached by a joint to the lever *d*, and working through a slot in the head of the standard; this piece *f*, has an inclined plane on the side next the end of the punch, which, in its descent, projects the punch forward against the top of the loop of the shank, (placed at *g*,) as the pincers are closed by forcing down the lever *d*, and, in conjunction with the jaws of the pincers, compresses the shank into the required form, as shown at *h*, and in the enlarged *fig.* 191. A spring, *i*, acts against a pin fixed into the punch *e*, for the purpose of bringing it back as the jaws open after forming a shank. *Figs.* 208 and 209 represent the face and section of the dies mentioned before, for cutting the slits in the discs, as at *fig.* 190.

Having explained the peculiar forms of his improved metallic shanks for buttons, and the tools employed in making the same, he proceeds to describe the machinery or apparatus by which he intends to carry his invention into effect. He proposes to take a sheet of metal, say about 30 or 40 feet long, and of the proper width and thickness; which thin sheet is to be wound upon a roller, and placed above the machine, so that it can be easily drawn down into the machine as required for feeding the punches and

dies. *Fig.* 210 is a plan view of a machine, intended to work any convenient number of sets of punches and dies placed in rows. Eleven sets of punches and dies are re-

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presented, each set being constructed as described under *figs.* 197 to 204; *fig.* 211 is a side view, and *fig.* 212 a longitudinal section, taken through the machine; *figs.* 213 and 214 are transverse sections taken through the machine between the punches and counter dies, *fig.* 213 representing its appearance at the face of the punches, and *fig.* 214 the opposite view of the counter dies. *a a* are the punches; *b b* the counter dies; each being mounted in rows in the steel plates *c c*, fixed upon two strong bars *d* and *e*, by countersunk screws and nuts, the punches and dies being retained in their proper position by the plates, which are screwed on to the front of the steel plates, and press against the collars of the punches and dies. The bars *d* and *e* are both mounted on the guide-pins *g g*, fixed in the heads *h h* of the frame, which guide pins pass through the bosses on the ends of the bars. The bar *d* is stationary upon the guide pins, being fixed to the heads *h h*, by nuts and screws passed through ears cast on their bosses. The bar *e* slides freely upon the guide pins *g g*, as it is

211

212

moved backwards and forwards by the crank *i i*, and connecting-rods *j j*, as the crank shaft revolves. The sheet of thin iron to be operated upon is placed, as before stated, above the machine; its end being brought down as at *a a*, and passed between the guide red

213

214

and clearing-plate *k*, and between the pair of feeding-rollers *l l*, which, by revolving, draw down a further portion of the sheet of metal between the punches and dies, after each operation of the punches.

As the counter dies advance towards the punches, they first come in contact with the sheet of metal to be operated upon; and after having produced the pressure which cuts out the discs, the perforations of the sheet are pushed on to the ends of the punches by the counter dies; and in order that the sheet may be allowed to advance, the carriage which supports the axles of the feeding rollers, with the guide rod and clearing-plate, are made to slide by means of the pin m, which works in a slot in the sliding-piece n, bearing the axis of the feeding-roller l l, the slide n being kept in its place on the framework by dovetailed guides shown in *fig.* 214.

When the counter dies have advanced near to the sheet of metal, the pin m comes in contact with that end of the slot in the piece n which is next to the punches, and forces the carriage with feed-rollers and clearing-plate, and also the sheet of metal, onwards, as the dies are advanced by the reaction of the cranks; and after they have cut out the discs, and raised the shanks, the sheet of metal will remain upon the punches; and when the bar e returns, the finished backs and shanks are forced out of the counter dies, by the clearing-pins and rods o o, which project through the bar e, and through the holes before mentioned in the counter dies; these clearing-pins being stationary between the bars p p, mounted upon the standard q q, on the cross bar of the frame, as shown in *figs.* 210, 212, 213. Immediately after this is done, the pins m come in contact with the other ends of the slots in the pieces n, and draw back the feeding-rollers l l, together with the clearing-plate k, and the sheet of metal, away from the punches into the position represented in the figures.

At this time the feeding of the metal into the machine is effected by a crank-pin, r, on the end of the crank-shafts coming in contact with the bent end of the sliding-bar s, supported in standards t t; and as the crank-shaft revolves, this pin r forces the bar s forward, and causes the tooth or pall u, on its reverse end, to drive the racket-wheel v, one or more teeth; and as the racket-wheel r is fixed on to the end of the axle of one of the rollers l, it will cause that roller to revolve; and by means of the pair of spur-pinions on the other ends of the axles of the feeding-rollers, they will both revolve simultaneously, and thereby draw down the sheet of metal into the machine. It will be perceived that the standards which support the clearing-plate and guide-bar are carried by the axles of the feeding-rollers, and partake of their sliding motion: also that the clearing-pins o, are made adjustable between the bars p, to correspond with the counter dies. There is an adjustable sliding stop x upon the bar s, which comes in contact with the back standard t, and prevents the bar s sliding back too far, and consequently regulates the quantity of sheet metal to be fed into the machine by the pall and ratchet-wheel, in order to suit different sizes of punches and dies. In case the weight of the bar c, carrying the counter dies, should wear upon its bearings, the guide pins g g, have small friction-rollers y y, shown under the bosses of this bar, which friction-rollers run upon adjustable beds or planes z z, by which means the guide pins may be partially relieved from the weight of the bar c, and the friction consequently diminished.

C.

CABLE. (*Cable*, Fr.; *Ankertau*, Germ.) A strong rope or chain, connecting the ship with the anchor for the purpose of mooring it to the ground. The *sheet anchor* cable is the strongest, and is used at sea; the *stream* cable is more slender, being used chiefly in rivers. A cable's length is 120 fathoms. The greatest improvement in mooring vessels has been the introduction of the chain cable, which, when duly let out, affords in the weight of its long catenary curve, an elastic tension and play to the ship under the pressure of wind. The dead strain upon the anchor is thus greatly reduced, and the sudden pull by which the flukes or arms are readily snapped is in a great measure obviated. The best iron cables are chains made of links, bound and braced by rods across their middle. Experience has taught that the ends of these links wear out much sooner than the sides. To remedy this evil, Mr. Hawkes, iron manufacturer, obtained a patent in July, 1828, for constructing these anchor chains with links considerably stouter at the ends than in the middle. With this view, he forms the short rods of iron, of which the links are to be made, with swells or protuberances about one third of their length from each of their ends, so that when these are welded together, the slenderer parts are at the sides, and the thicker at the ends of the elliptic links. Such rods as the above are formed at once by rolling, swagging, or any other means. When the link is welded, it may be strengthened, by a brace or stretcher fixed across the middle.

The first avowed proposal to substitute iron cables for cordage in the sea service, was made by Mr. Slater, surgeon of the navy, who obtained a patent for the plan in 1808, though he does not seem to have had the means of carrying it into effect; a very general misfortune with ingenious projectors. It was Captain Brown of the West India

merchant service who, in 1811, first employed chain cables in the vessel Penelope, of 400 tons burden, of which he was captain. He made a voyage in this ship from England to Martinique and Guadaloupe and home again, in the course of four months, having anchored many times in every variety of ground without any accident. He multiplied his trials, and acquired certain proofs that iron might be substituted for hemp in making cables, not only for mooring vessels, but for the standing rigging. Since this period chain cables have been universally introduced into all the ships of the royal navy, but the twisted links employed at first by Brown have been replaced by straight ones, stayed in the middle with a cross rod, the contrivance of Mr. Brunton, which was secured by patent in this country and in France; but the latter patent was suffered to fall from not being acted upon within the two years specified by law.

The first thing to be considered in the manufacture of iron cables is, to procure a material of the best quality, and, in using it, always to keep in view the direction of the strain, in order to oppose the maximum strength of the iron to it. The best form of the links may be deduced from the following investigation.

215 M
Let A B, *fig.* 215, be a circular link or ring, of one inch rod iron, the outer circumference of the ring being 15 inches, and the inner 9. If equal opposite forces be applied to the two points of the link c D, pulling c towards E, and D towards F, the result will be, when the forces are sufficiently intense, that the circular form of the link will be changed into another form with two round ends and two parallel sides, as seen in *fig.* 216. The ratio of the exterior to the interior periphery, which was originally as 15 to 9, or 5 to 3, is no longer the same in *fig.* 216. Hence there will be a derangement in the relative position of the component particles, and consequently their cohesion will be progressively impaired, and eventually destroyed. In *fig.* 215, the segment M N of the outside periphery being equal to 3 inches, the corresponding inside segment will be $\frac{3}{5}$ of it, or $1\frac{4}{5}$ inches. If this portion of the link, in consequence of the stretching force, comes to be extended into a straight line, as shown in *fig.* 216, the corresponding segments, interior and exterior, must both be reduced to an equal length. The matter contained in the 3 inches of the outside periphery must therefore be either compressed, that is, condensed into $1\frac{4}{5}$ inches, or the inside periphery, which is only $1\frac{4}{5}$ inches already, must be extended to 3 inches; that is to say, the exterior condensation and the interior expansion must take place in a reciprocal proportion. But, in every case, it is impossible to effect this connection of one side of the rod, and extension of the other, without disrupture of the link.
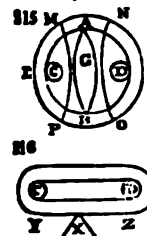
Let us imagine the outside periphery divided into an infinity of points, upon each of which equal opposite forces act to straighten the curvature: they must undoubtedly occasion the rupture of the corresponding part of the internal periphery. This is not the sole injury which must result; others will occur, as we shall perceive in considering what passes in the portion of the link which surrounds c D, *fig.* 216, whose length is $4\frac{1}{2}$ inches outside, and $2\frac{1}{10}$ inside. The segments M P and N O, *fig.* 215, are actually reduced to semi-circumferences, which are inside no more than half an inch, and outside as before. There is thus contraction in the interior, with a quicker curvature or one of shorter radius in the exterior. The derangement of the particles takes place here, in an order inverse to that of the preceding case, but it no less tends to diminish the strength of that portion of the link; whence we may certainly conclude that the circular form of cable links is an extremely faulty one.

Leaving matters as we have supposed in *fig.* 215, but suppose that G is a rod introduced into the mail, hindering its two opposite points A B from approximating. This circumstance makes a remarkable change in the results. The link pulled as above described, must assume the quadrilateral form shown in *fig.* 217. It offers more resistance to deformation than before; but as it may still suffer change of shape, it will lose strength in so doing, and cannot therefore be recommended for the construction of cables which are to be exposed to very severe strains.

Supposing still the link to be circular, if the ends of the stay comprehended a larger portion of the internal periphery, so as to leave merely the space necessary for the play of the next link, there can be no doubt of its opposing more effectively the change of form, and thus rendering the chain stronger. But, notwithstanding, the circular portions which remain between the points of application of the strain and the stay, would tend always to be straightened, and of consequence to be destroyed. Besides, though we could construct circular links of sufficient strength to bear all strains, we ought still to reject them; because they would consume more materials than links of a more suitable form, as we shall presently see.

The effect of two opposite forces applied to the links of a chain, is, as we have seen,

14

to reduce to a straight line or a straight plane every curved part which is not stayed; whence it is obvious that twisted links, such as Brown first employed, even with a stay in their middle, must of necessity be straightened out, because there is no resistance in the direction opposed to the twist. A cable formed of twisted links, for a vessel of 400 tons, stretches 30 feet, when put to the trial strain, and draws backs only 10 feet. This elongation of 20 feet proceeds evidently from the straightening of the twist in each link, which can take place only by impairing the strength of the cable.

From the preceding remarks, it appears that the strongest links are such as present, in their original form, straight portions between the points of tension; whence it is clear that links with parallel sides and round ends would be preferable to all others, did not a good cable require to be able to resist a lateral force, as well as one in the direction of its length.

Let us suppose that by some accident the link *fig.* 216 should have its two extremities

pulled towards Y and Z, whilst an obstacle X, placed right opposite to its middle, resisted the effort. The side of the link which touches X would be bent inwards; but if, as in *fig.* 218, there is a stay A G B, the two sides would be bent at the same time; the link would notwithstanding assume a faulty shape.

In thus rejecting all the vicious forms, we are naturally directed to that which deserves the preference. It is shown in *fig.* 219. This link has a cast-iron stay with large ends;

it presents in all directions a great resistance to every change of form; for let it be pulled in the direction *a b*, against an obstacle *c*, it is evident that the portions *d e* and *d f*, which are supported by the parts *g e* and *g f*, cannot get deformed or be broken without the whole link giving way. As the matter composing *g e* and *g f* cannot be shortened, or that which composes *d e* and *d f* be lengthened, these four sides will remain necessarily in their relative positions, by virtue of the large-ended stay *h*, whose profile is shown in *fig.* 220.
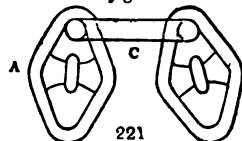
We have examined the strength of a link in every direction, except that perpendicular to its plane. *Fig.* 221 represents the assemblage of three links in the above predicament; but we ought to observe that the obstacle c, placed between the links A B, must be necessarily very small, and could not, therefore, resist the pressure or impact of the two lateral links.

Process of manufacturing iron cables.—The implements and operations are arranged in the following order :—

1. A reverberatory furnace (see IRON), in which a number of rods or round bars of the best possible wrought-iron, and of proper dimensions, are heated to bright ignition.

2. The cutting by a machine of these bars, in equal lengths, but with opposite bevels, to allow of the requisite crossing and splicing of the ends in the act of welding.

3. The bending of each of these pieces by a machine, so as to form the links; the last two operations are done rapidly while the iron is red-hot.

4. The welding of the links at small forge fires, fitted with tools for this express purpose, and the immediate introduction of the stay, by means of a compound lever press.

5. Proving the strength of the cables by an hydraulic press, worked by two men turning a winch furnished with a fly-wheel.

The furnace is like those used in the sheet-iron works, but somewhat larger, and needs no particular description here.

Figs. 222 and 223 are a plan and elevation of the shears with which the rods are cut
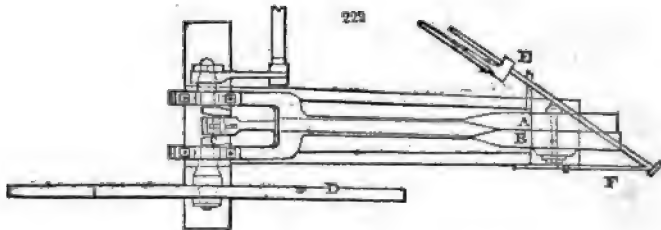
into equal pieces, for forming each a link. It is moved at Mr. Brunton's factory by a small steam engine, but, for the sake of simplicity, it is here represented worked by four or more laborers, as it may be in any establishment. These must be relieved, however,

frequently by others, for I believe each shears' machine is calculated to require nearly one horse in steam power. It is portable, and must be placed in the neighborhood of both the furnace and bending machine.

A and B are the two cast-iron limbs of the shears. The first is fixed, and the second is moveable by means of a crank shaft c, driven by a heavy fly-wheel weighing 7 or 8 cwt.

223
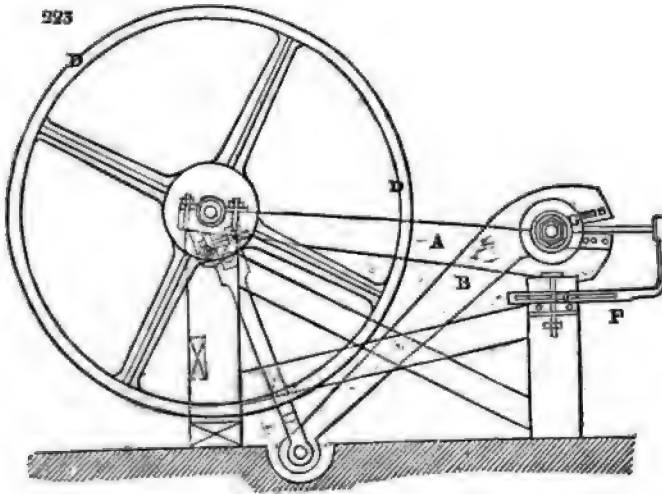
The cutting jaws G are mounted with pieces of steel which are made fast by bolts, and may be changed at pleasure.

E, the bar of iron to be cut. It is subjected, immediately upon being taken out of the fire, to the shears, under a determinate uniform angle, care being taken not to let it turn round upon its axis, lest the planes of the successive incisions should become unequal.

F is a stop which serves to determine, for the same kind of chain, the equality of length in the link pieces.

Figs. 224, 225, 226, plan and elevations of the machine for bending the links into an elliptic form. It is represented at the moment when a link is getting bent upon it.

224 225 226
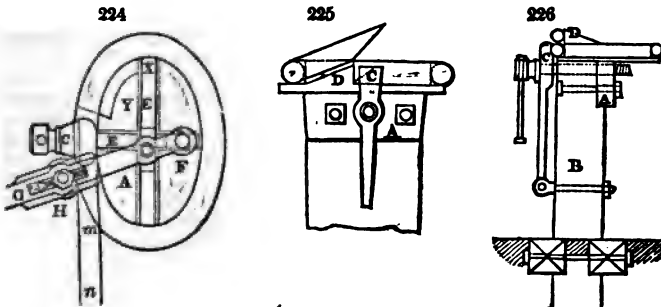
A is an elliptic mandrel of cast-iron; it is fixed upon the top of a wooden pillar B, solidly supported in the ground. c is the jaw of the vice, pressed by a square-headed screw against the mandrel A.

D part of the mandrel comprehended between x and Y, formed as an inclined plane, so as to preserve an interval equal to the diameter of the rod between the two surfaces that are to be welded together.

E rectangular slots (shears) passing through the centre of the nut of the mandrel, in which each of the pins F may be freely slidden.

G horizontal lever of wrought-iron six feet long. It carries at H a pulley or friction-roller of steel, whose position may be altered according to the diameter of the links. It is obvious that as many mandrels are required as there are sizes and shapes of links.

The piece of iron intended to form a link being cut, is carried, while red-hot, to the bending machine, where it is seized with the jaw of the vice c, by one of its ends, the slant of the cut being turned upwards; this piece of iron has now the horizontal direction *m n;* on pushing the lever o in the line of the arrow, the roller H will force *m n* to be applied successively in the elliptic groove of the mandrel; thus finally the two faces that are to be welded together will be placed right opposite each other.

The length of the small diameter of the ellipse ought to exceed by a little the length of the stay-piece, to allow of this being readily introduced. The difference between the points F E, is equal to the difference of the *radii vectores* of the ellipse. Hence it will be always easy to find the eccentricity of the ellipse.

Fig. 227 is a lever press for squeezing the links upon their stays, after the links are

227
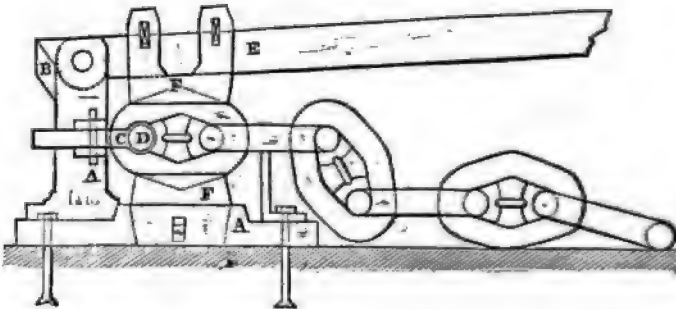
welded. This machine consists of a strong cast-iron piece A, in the form of a square, of which one of the branches is laid horizontally, and fixed to a solid bed by means of bolts; the other branch, composed of two cheeks, leaving between them a space of two inches, stands upright. These two cheeks are united at top, and on the back of their plane by a cross piece B. c, a rectangular staple, placed to the right and left of the cheeks through which is passed the mandrel D, which represents and keeps the place of the following link. E, is a press lever, 6 feet long. F, clamp and counterclamp, between which the link is pressed at the moment when the stay is properly placed. There are other clamps, as well as staples c, for changing with each changed dimension of links.

The links bent, as we have seen, are carried to the forge hearth to be welded, and to receive their stay; two operations performed at one heating. Whenever the welding is finished, while the iron is still red-hot, the link is placed upright between the clamps F; then a workman introduces into the staple the mandrel D, and now applies the stay with a pair of tongs or pincers, while another workman strikes down the lever E forcibly upon it. This mechanical compression first of all joins perfectly the sides of the link against the concave ends of the stay, and afterwards the retraction of the iron on cooling increases still more this compression.

If each link be made with the same care, the cable must be sound throughout. It is not delivered for use, however, till it be proved by the hydraulic press, at a draw-bench made on purpose. The press is a horizontal one, having the axis of its ram in the middle line of the draw-bench, which is about 60 feet long, and is secured to the body of the press by strong bolts.

The portion of chain under trial, being attached at the one end to the end of the ram of the press, and at the other to a cross-bar at the extremity of the draw-bench, two men put the press in action, by turning the winch, which works by a triple crank three forcing pumps alternately; the action being equalized by means of a heavy fly-wheel. As long as the resistance does not exceed the force of two men, the whole three pumps are kept in play. After a while one pump is thrown out of gear and next another, only one being worked towards the conclusion. The velocity of the ram being retarded first one third and next two thirds, gives the men a proportional increase of mechanical power.

The strength of two average men thus applied being computed, enables us to know at every instant the resistance opposed by the chain to the pressure of the ram. The strain usually applied to the stronger cables is about 500 tons.

The side beams of the draw-bench are of cast-iron, 6 inches in diameter; the different pieces composing it are adjusted to each other endwise by turned joints. Props also of cast-iron support the beams two feet asunder, and at the height of 30 inches above the ground. The space between them is filled with an oak plank on which the trial chain is laid.

Strength of iron cables compared to hemp cables :—

Iron Cables. Diameter of Iron Rod.	Hemp Cables. Circumference of Rope.	Resistance.
Inches.	Inches.	Tons.
0⅞	9	12
1	10	18
1⅛	11	26
1¼	12	32
1 5/16	13	35
1⅜	14 to 15	38
1½	16	44
1⅝	17	52
1¾	18	60
1⅞	20	70
2	22 to 24	80

It would be imprudent to put hemp cables to severer strains than those indicated in the preceding table, drawn up from Brunton's experiments; but the iron cables of the above sizes will support a double strain without breaking. They ought never in common cases, however, to be exposed to a greater stress. A cable destined for ships of a certain tonnage, should not be employed in those of greater burden. Thus treated it may be always trusted to do its duty, and will last longer than the ship to which it belongs. A considerable part of this decided superiority which iron cables have over hemp ones, is undoubtedly due to the admirable form contrived by Brunton. Repeated experiments have proved that his cables possess double the strength of the iron rods with which they are made — a fact which demonstrates that no stronger form can be devised or is in fact possible.

One of the most valuable qualities of iron cables is their resisting lateral as well as longitudinal strains, as explained under figs. 219 and 221.

Vessels furnished with such cables have been saved by them from the most imminent peril. The Henry, sent out with army stores during the peninsular war, was caught on the northern coast of Spain in a furious storm. She run for shelter into the Bay of Biscay among the rocks, where she was exposed for three days to the hurricane. She possessed fortunately one of Brunton's 70 fathom chain cables, which held good all the time, but it was found afterwards to have had the links of its lower portion polished bright by attrition against the rocky bottom. A hemp cable would have been speedily torn to pieces in such a predicament.

In the contracts of the Admiralty for chain cables for the British navy, it is stipulated that "the iron shall have been manufactured in the best manner from pig iron, smelted from iron-stone only, and selected of the best quality for the purpose, and shall not have received, in any process whatever subsequent to the smelting, the admixture of either the cinder or oxydes produced in the manufacture of iron ; and shall also have been puddled in the best manner upon iron bottoms, and at least three times sufficiently drawn out at three distinct welding heats, and at least twice properly fagoted."

The following is a table of the breaking proof of chain cables, and of the iron for the purpose of making them, also of the proofs required by her majesty's navy for chains.

Size of Bolt.	Proof of Bolt.		Proof of Chain.		Navy Proof of Chain.
Inches.	Tons.	Cwt.	Tons.	Cwt.	Tons.
½	5	7	8	11	4½
⅝	8	7	13	4	5½
¾	12	1	19	5	10⅛
⅞	16	4	26	5	13¾
1	21	8	34	5	18
1⅛	27	2	48	15	22¾
1¼	33	10	53	11	28¼
1⅜	40	10	65	0	34
1½	48	4	77	0	40½
1⅝	56	11	90	10	47½
1¾	65	12	105	0	55⅛
1⅞	75	6	120	10	63¼
2	85	14	137	0	72
2¼	96	15	155	0	81¼

In Brunton's cable the matter in the link is thrown very much into one plane; the

link being of an oval form, and provided with a stay. As there are emergencies in which the cable must be severed, this is accomplished in those of iron by means of a bolt and sheckle (shackle), at every fathom or two fathoms; so that by striking out this bolt or pin, this cable is parted with more ease than a hempen one can be cut.

CACAO, BUTTER OF. See Cocoa, and Oils, Unctuous.

CADMIUM is a metal discovered about the beginning of the year 1818. It occurs chiefly in Silesia in several ores of zinc; and may be readily recognised by means of the blowpipe; for at the first impression of the reducing or smoky part of the flame, the ores containing cadmium stain the charcoal all round them with a reddish yellow circle of oxyde of cadmium. The Silesian native oxyde of zinc contains from 1¼ to 11 per cent. of cadmium.

The cadmium may be extracted by dissolving the ore in sulphuric acid, leaving the solution acidulous, and diluting it with water, then transmitting through it a stream of sulphureted hydrogen, till the yellow precipitate ceases to fall. This powder, which is sulphuret of cadmium, is to be dissolved in concentrated muriatic acid, the excess of which is to be expelled by evaporation; and the muriatic salt being dissolved in water, carbonate of ammonia is to be added in excess, whereby the cadmium separates as a carbonate, while the small portion of adhering copper or zinc is retained in solution by the ammonia. Herapath has shown, that in distilling zinc *per descensum* (see Zinc), the first portions of gaseous metal which are disengaged burn with a brown flame and deposite the brown oxyde of cadmium.

Cadmium has the color and lustre of tin, and is susceptible of a fine polish. Its fracture is fibrous; it crystallizes readily in regular octahedrons, and when it suddenly solidifies, its surface gets covered with fine mossy vegetations. It is soft, easily bent, filed, and cut, soils like lead any surface rubbed with it. It is harder and more tenacious than tin, and emits a creaking sound when bent, like that metal. It is very ductile, and may be drawn out into fine wire, and hammered into thin leaves without cracking at the edges. Its specific gravity, after being merely melted, is 8·604; and 8·6944 after it has been hammered. It is very fusible, melting at a heat much under redness; indeed, at a temperature little exceeding that of boiling mercury, it boils and distils over in drops. Its vapors have no smell. It is but slightly altered by exposure to air. When heated in the atmosphere, it readily takes fire, and burns with a brownish yellow smoke which is destitute of smell. In strong acids it dissolves with disengagement of hydrogen, and forms colorless solutions. Chromate of potash causes no precipitate in them, unless zinc or lead be present.

There is only one oxyde of cadmium, the brown above mentioned. Its specific gravity is 8·183. It is neither fusible nor volatile at a very high temperature. When in the state of a hydrate it is white. The oxyde of cadmium consists of 87·45 parts of metal, and 12·55 oxygen in 100 parts. Berzelius states its atomic weight to be 55·833 to hydrogen 1·000. Its sulphuret has a fine orange yellow color, and would form a beautiful pigment, could the metal be found in sufficient quantity for the purposes of art. The sulphate is applied to the eyes by surgeons for removing specks of the cornea.

CAFEINE. A chemical principle discovered in coffee, remarkable for containing much azote. See Coffee.

CAJEPUT OIL is obtained from the leaves of the tree called Melaleuca Leucadendron by Linnæus, which grows upon the mountains of Amboyna, and in other of the Molucca islands. It is procured by distillation of the dried leaves along with water, is prepared in great quantities in the island of Banda, and sent to Holland in copper flasks. Hence, as it comes to us, it has a green color. It is very limpid, lighter than water, of a strong smell resembling camphor, and pungent taste like cardamoms. When rectified the copper remains in the retort, and the oil comes over colorless. It is used in medicine as a stimulant. See Oils Ethereous.

CALAMANCO. A sort of woollen stuff of a shining appearance, checkered in the warp, so that the checks are seen only upon one side.

CALAMINE. A native carbonate of zinc. See Zinc.

CALCAREOUS EARTH, (*Terre calcaire*, Fr.; *Kalkerde*, Germ.), commonly denotes lime, in any form; but, properly speaking, it is pure lime.

CALCAREOUS SPAR. Crystallized native carbonate of lime.

CALCEDONY. A hard mineral of the silicious family, often cut into seals. Under it may be grouped common calcedony, heliotrope, chrysoprase, plasma, onyx, sardonyx, and sard.

CALCHANTUM. The ancient name of native copperas or sulphate of iron.

CALCINATION is the chemical process of subjecting metallic bodies to heat with access of air, whereby they are converted into a pulverulent matter, somewhat like lime in appearance, called *calx* in Latin. The term calcination, however, is now used when any substance whatever is exposed to a roasting heat.

CALCIUM. The metallic basis of lime. See Lime.

CALC-SINTER. The incrustations of carbonate of lime upon the ground, or the pendulous conical pieces called stalactites, attached to the roofs of caverns, are so called.

CALC-TUFF. A semi-hard, irregular deposite of carbonate of lime, formed from the waters of calcareous springs.

CALCULUS. The stony-looking morbid concretion, occasionally formed in the bladder of urine, gall-bladder, cystic duct, kidneys, and other parts of living animals. Its examination belongs to medical chemistry.

CALENDER (*Calandre*, Fr.; *Kalander*, Germ.), a word derived from the Greek *kalindros* (cylinder), is the name of a machine, consisting of two or more cylinders, revolving so nearly in contact with each other that cloth passed through between them is smoothed, and even glazed, by their powerful pressure. It is employed either to finish goods for the market, or to prepare cotton and linen webs for the calico-printer, by rendering their surfaces level, compact, and uniform. This condensation and polish, or *satinage*, as the French call it, differ in degree according to the object in view, and may be arranged into three distinct series. 1. For goods which are to receive the first impression by the block, a very strong pressure is required; for, upon the uniformity of the polish, the neatness and regularity of the printing, and the correspondence of its members, depend. In many establishments the calico is passed twice through the calender before being sent to the tables. 2. The pieces already dyed up at the madder bath, or otherwise, and which remain to be filled in with other colors, or *grounded-in*, as it is technically styled, must receive a much less considerable gloss. This is a principle everywhere admitted and acted upon, because the outline of the figured design being deranged by the washing, and sometimes in consequence of the peculiar texture of the cloth, the printer, in order to apply his grounding blocks properly, and to fit them to the contours of the figures already impressed, is obliged to stretch the piece sometimes in the direction of the warp, and sometimes of the weft, which would be impossible if they had been hard glazed by the calender. 3. The degree of glazing given to finished goods depends upon the taste of purchasers, and the nature of the article; but it is, in general, much less than for the first course of block-printing.

The most complete calender probably in existence is that used by some of the eminent calico-printers of Alsace, as contrived by M. Charles Dollfus, and constructed by MM. Witz, Blech, and Co. 1. It passes two pieces at once, and thus does double the work of any ordinary machine. 2. It supersedes the necessity of having a workman to fold up the goods, as they emerge from the calender, with the aid of a self-acting folder. 3. It receives, at pleasure, the finished pieces upon a roller, instead of laying them in folds; and, by a very simple arrangement, it hinders the hands of the workmen from being caught by the rollers.

Calenders, in consequence of the irregular demand for foreign orders and shipments, are worked very irregularly, being sometimes overloaded with duty, and at others altogether unemployed. A machine which can, when required, turn out a double quantity of goods, must, therefore, be a desirable possession. For the first course of the printers, where high calendering is necessary, the goods are usually passed twice through between two paper cylinders, to give that equality of surface which could not be obtained by one passage, however strong the pressure; and therefore the simplification of this calender will prove no economy. Besides, in order to increase the pressure to the requisite degree, the cylinders would need to be made bulging at their middle part, and with such cylinders common smoothing could not be given; for the pieces would be glazed in the central line, and rough towards the edges. For pieces already printed in part, and requiring only to be grounded-in for other colors, the system of double effect has fewer objections, as a single passage through the excellent calender described under BLEACHING, page 140, is found to answer very well.

The most remarkable feature of M. Dollfus's machine is its being managed by a single workman. Six or eight pieces are coiled upon the feed-roller, and they are neither pasted nor stitched together, but the ends are merely overlapped half a yard or so. The workman is careful not to enter the second piece till one third or one half of the first one has passed through on the other side, to prevent his being engrossed with two ends at a time. He must, no doubt, go sometimes to the one side, and sometimes to the other of the machine, to see that no folds or creases occur, and to be ready for supplying a fresh piece as the preceding one has gone through. The mechanism of the folder in the Alsace machine is truly ingenious: it performs extremely well, really saves the attendance of an extra workman, and is worthy the attention of manufacturers intent upon economizing hand labor. The lapping-roller works by friction, and does its duty fully better than similar machines guided by the hand.

The numerous accidents which have happened to the hands of workmen engaged in calenders should direct the attention towards its effective contrivance for preventing such misfortunes. These various improvements in the Alsace machine may be easily adapted to the ordinary calenders of almost every construction.

The folder is a kind of cage, in the shape of an inverted pyramid, shut on the four sides, and open at top and bottom; the top orifice is about five inches, the bottom one an inch and a half; the front and the back, which are about four feet broad, are made of tin-plate or smooth pasteboard, and the two sides are made of strong sheet-iron; the whole being bolted together by small bars of iron. Upon the sheet-iron of the sides, iron uprights are fixed, perforated with holes, through which the whole cage is supported freely by means of studs that enter into them. One of the uprights is longer than the other, and bears a slot with a small knob, which, by means of the iron piece, joins the guide to the crank of the cylinder, and thereby communicates to the cage a seesaw movement; at the bottom extremity of the great upright, there is a piece of iron in the shape of an anchor, which may be raised, or lowered, or made fast, by screws.

At the ends of this anchor are friction-rollers, which may be drawn out or pushed back and fixed by screws; these rollers lift alternately two levers made of wood, and fixed to a wooden shaft.

The paws are also made of wood: they serve to lay down alternately the plies of the cloth which passes upon the cage, and is folded zigzag upon the floor, or upon a board set below the cage; a motion imparted by the seesaw motion of the cage itself. See STRETCHING MACHINE.

To protect the fingers of the workmen, above the small plate of the spreading-board or bar, there is another bar, which forms with the former an angle of about 75°; they come sufficiently near together for the opening at the summit of the angle to allow the cloth to pass through, but not the fingers. See *Bulletin de la Société Industrielle de Mulhausen*, No. 18.

I shall now describe, more minutely, the structure of the powerful but less complicated calender mechanisms employed in the British manufactories.

A front elevation of a four-rollered calender (five rollers are often introduced) for glazing goods is given in *fig.* 228. *d l* are two pasteboard or paper cylinders, each 20 inches
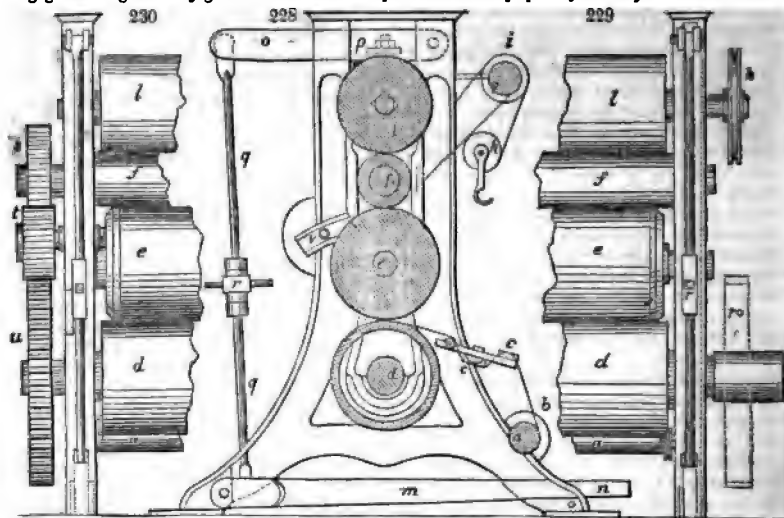
in diameter, whose structure will be presently described : *f* is a cast-iron cylinder turned perfectly smooth (its fellow is often placed between *e* and *d*) : it is eight inches in diameter outside, four inches inside, with two inches thickness of metal. *e* is another pasteboard cylinder, fourteen inches in diameter: the strong cast-iron frame contains the bushes in which the journals of the rollers turn. *o p*, is one of the pair of levers for communicating a graduated pressure according to the quality of the goods. *Figs.* 229, 230, are end views of the same machine to show the working gear. The wheel *s*, on the end of the upper iron cylinder, is ten inches in diameter; that on the end of the fellow iron cylinder below (when it is present) is thirteen inches; both are connected by the larger carrier wheel *t*. The lower wheel *u* is one third larger than the upper wheel, and therefore receives from the carrier wheel *t*, a proportionally slower motion, which it imparts to the central pasteboard roller *e*, lying upon it, causing it to move one third more slowly than the upper pasteboard roller. Thus a sort of sliding motion is produced, which, by rubbing their surfaces, glazes the goods.

The iron rollers are made hollow for the purpose of admitting either a hot roller of

iron, or steam when hot calendering is required. The other cylinders used formerly to be made of wood, but it was liable to many defects. The advantage of the paper roller consists in its being devoid of any tendency to split, crack, or warp, especially when exposed to a considerable heat from the contact and pressure of the hot iron rollers. The paper, moreover, takes a vastly finer polish, and, being of an elastic nature, presses into every pore of the cloth, and smooths its surface more effectually than any wooden cylinder, however truly turned, could possibly do.

The paper cylinder is constructed as follows :—The axis of the cylinder is a strong square bar of the best wrought iron, cut to the proper length. Upon this bar a strong round plate of cast iron is first put, somewhat less in diameter than the cylinder when finished. A quantity of thick stout pasteboard is then procured, and cut into round pieces an inch larger in diameter than the iron plate. In the centre of the plates, and of every piece of the pasteboard, a square hole must be cut to receive the axis; and, the circle being divided into six equal parts, a hole must also be cut at each of the divisions, an inch or two within the rim. These pieces of pasteboard being successively put upon the axis, a long bolt of malleable iron, with a head at one end, and screwed at the other, is also introduced through each of the holes near the rim; and this is continued until a sufficient number of pasteboards are thus placed to form a cylinder of the length required, proper allowance being made for the compression which the pasteboard is afterwards to undergo. Another round plate is then applied, and, nuts being put upon the screws, the whole are screwed tight, and a cylinder formed. This cylinder is now to be placed in a stove, exposed to a strong heat, and must be kept there for at least several days; and, as the pasteboard shrinks by exposure to the heat, the screws must be frequently tightened until the whole mass has been compressed as much as possible. When the cylinder is thus brought to a sufficient degree of density, it is removed from the stove; and, when allowed to cool, the pasteboard forms a substance almost inconceivably dense and hard. Nothing now remains but to turn the cylinder; and this is an operation of no slight labor and patience. The motion in turning must be slow, not exceeding about forty revolutions in a minute; the substance being now so hard and tough that tools of a very small size must be used to cut, or rather scrape it, until it is true. Three men are generally employed for the turning, even when the motion of the cylinder is effected by mechanical power, two being necessary to sharpen tools for the third, who turns, as quickly as he blunts them.

Let us suppose it to be a five-rollered machine: when a person stands in front of the calender, the cloth coming from behind above the uppermost cylinder 1, passes between 1 and 2: proceeding behind 2, it again comes to the front between 2 and 3: between 3 and 4 it is once more carried behind, and, lastly, brought in front between 4 and 5, where it is received, and smoothly folded on a clean board, or in a box, by a person placed there for the purpose. In folding the cloth at this time, care must be taken that it may be loosely done, so that no mark may appear until it be again folded in the precise length and form into which the piece is to be made up. The folding may be done either by two persons or by one, with the aid of two sharp polished spikes placed at a proper distance, to ascertain the length of the fold, and to make the whole equal. When folded into lengths, it is again folded across upon a smooth clean table, according to the shape intended, which varies with the different kinds of goods, or the particular market for which the goods are designed.

When the pieces have received the proper fold, the last operation previous to packing them is the pressing. This is commonly performed by placing a certain number of pieces, divided by thin smooth boards of wood, in a common screw press, similar to those used by printers for taking out the impression left by the types in the printing-press. Besides the wooden boards, a piece of glazed pasteboard is placed above and below every piece of cloth, that the outer folds may be as smooth and glossy as possible. The operation of the common screw press being found tedious and laborious, the hydraulic press is now in all well-mounted establishments had recourse to. See HYDRAULIC PRESS.

No improvements that have taken place in calendering can exceed the power and facility of the water press: one of these presses may be worked by two men, who can with great ease produce a pressure of 400 tons; but, in considerable establishments, the presses are worked by power. See BANDANNA.

The appearance and finish of the goods, in consequence of such an immense weight acting on them, are materially improved.

The press is also used for the purpose of packing; whereby the bale is rendered much more compact than formerly. It is commonly roped, &c., while in this compressed state; the dimensions are therefore greatly diminished from what they would otherwise be by any other method. For instance, the same quantity of goods packed in a bale are from one third to one half less bulky than if they were packed in a box with the utmost force of the hands.

For lawns and muslins of a light texture, the operation of smoothing requires a different process in some respects than close heavy fabrics. They only require to be slightly smoothed to remove any marks which they may have received at the bleaching; and as their beauty depends rather on their transparency than their closeness, the more the cylindrical form of the yarn is preserved the better. They are therefore put through a small machine, consisting of three rollers or cylinders; and as the power required to move this is small, the person who attends it generally drives it by a small winch; or the same effect may be produced by passing the muslins between only two or three rollers of the above calender, lightly loaded.

In the thick fabrics of cloth, including those kinds which are used for many parts of household furniture, as also those for female dress, the operation of glazing is used both to add to the original beauty of the cloth, and to render it more impervious to dust or smoke. The glazing operation is performed entirely by the friction of any smooth substance upon the cloth; and, to render the gloss brighter, a small quantity of bleached wax is previously rubbed over the surface. The operation of glazing by the common plan is very laborious, but the apparatus is of the most simple kind. A table is mounted with a thick stout cover of level and well-smoothed wood, forming an inclined plane; that side where the operator stands at work being the lowest. The table is generally placed near a wall, both for convenience in suspending the glazing apparatus, and for the sake of light. A long piece of wood is suspended in a groove formed between two longitudinal beams, placed parallel to the wall, and fixed to it. The groove resembles exactly the aperture between the shears of a common turning lathe. The lever, of which the groove may be supposed to be the centre or fulcrum, is faced at the bottom with a semi-cylindrical piece of finely polished flint, which gives the friction to the cloth stretched upon the table below. Above the flint are two cross handles, of which the operator lays hold, and moves them backward and forward with his hands, keeping the flint pressing slightly upon the cloth. When he has glazed a portion equal to the breadth of the flint, he moves his lever between the shears sidewise, and glazes a fresh part: thus he proceeds from one side or selvage of the cloth to the other; and when all which is upon the table is sufficiently glazed, he draws it over, and exposes a new portion to the same operation. To preserve the cloth at a proper tension, it may be wound smoothly upon a roller or beam, which being set so as to revolve upon its own axis behind the table, another roller to receive the cloth may be placed before, both being secured by a catch, acting in a ratchet wheel. Of late years, however, a great part of the labor employed in glazing cloth has been saved, as the common four or five bowl calender has been altered to fit this purpose by direct pressure.

As a matter of accommodation, the different processes of packing, cording of boxes, sheeting of trunks, and, in general, all the arrangements preparatory to shipments, and also the intimations and surveys necessary for obtaining drawbacks, debentures, or bounties, according to the excise laws, are generally conducted at the calender houses where goods are finished. These operations sufficiently account for the general meaning attached to the word.

CALICO-PRINTING (*Impression d'Indiennes*, Fr.; *Zeugdruckerei*, Germ.) is the art of impressing cotton cloth with topical dyes of more or less permanence. Of late years, silk and woollen fabrics have been made the subjects of a similar style of dyeing. Linens were formerly stained with various colored designs, but since the modern improvements in the manufacture of cotton cloth, they are seldom printed, as they are both dearer, and produce less beautiful work, because flax possesses less affinity than cotton for coloring matters.

This art is of very ancient date in India, and takes its English name from Calicut, a district where it has been practised with great success from time immemorial. The Egyptians, also, appear from Pliny's testimony to have practised at a remote era some of the most refined processes of topical dyeing. "Robes and white veils," says he, "are painted in Egypt in a wonderful way. They are first imbued, not with dyes, but with dye-absorbing drugs, by which, though they seem to be unaltered, yet, when immersed for a little while in a caldron of the boiling dye-liquor, they are found to become painted. Yet, as there is only one color in the caldron, it is marvellous to see many colors imparted to the robe, in consequence of the influence of the excipient drug. Nor can the dye be washed out. A caldron, which would of itself merely confuse the colors of cloths previously dyed, is thus made to impart several pigments from a single dye-stuff, *painting as it boils*." The last expression, *pingit, dum coquit*, is perfectly graphic and descriptive of calico-printing.

The cotton chints counterpanes of great size, called *pallampoors*, which have been manufactured in Madras from the earliest ages, have in like manner peculiar dye-absorbing drugs applied to them with the pencil, as also wax, to protect certain parts of the surface from the action of the dye, and are afterwards immersed in a staining liquor, which, when wax is applied, is usually the cold indigo-vat, but without the wax is a hot liquor similar to the Egyptian. M. Kœchlin Roder, of Mulhouse, brought home lately from

India a rich collection of cloths in this state of preparation, which I saw in the cabinet of the *Société Industrielle* of that interesting emporium of calico-printing. The native implements for applying the wax and coloring bases are placed along-side of the cloths, and form a curious picture of primeval art. There is among other samples an ancient *pallampoor*, five French yards long, and two and a half broad, said to be the labor of Hindoo princesses, which must have taken a lifetime to execute. The printing machinery of great Britain has begun to supersede, for these styles of work, the cheapest hand labor of India.

Calico-printing has been for several hundred years practised by the oriental methods in Asia Minor and the Levant; but it was unknown as an English art till 1696, when a small print-ground was formed upon the banks of the Thames, near Richmond, by a Frenchman—probably a refugee from his own country, in consequence of the revocation of the edict of Nantes. Some time afterwards, a considerable printing work was established at Bromley Hall, in Essex, and several others sprung up succes-sively in Surrey, to supply the London shops with chintses, their import from India having been prohibited by act of parliament in 1700. The silk and woollen weavers, indeed, had all along manifested the keenest hostility to the use of printed calicoes, whether brought from the East or made at home. In the year 1680 they mobbed the India House in revenge for some large importations then made of the chintses of Malabar. They next induced the government, by incessant clamors, to exclude alto-gether the beautiful robes of Calicut from the British market. But the printed goods, imported by the English and Dutch East India companies, found their way into this country, in spite of the excessive penalties annexed to smuggling, and raised a new alarm among the manufacturing population of Spitalfields. The sapient legislators of that day, intimidated, as would appear, by the East London mobs, enacted in 1720 an absurd sumptuary law, prohibiting the *wearing of all printed calicoes whatsoever, either of foreign or domestic origin*. This disgraceful enactment, worthy of the meridian of Cairo or Algiers, proved not only a death-blow to rising industry in this ingenious department of the arts, but prevented the British ladies from attiring themselves in the becoming drapery of Hindostan. After an oppressive operation of ten years, this act was repealed by a partially enlightened set of senators, who were then pleased to permit what they called British calicoes, if made of linen warp, with merely weft of the *hated* cotton, to be printed and worn, upon paying a duty of no less than sixpence the square yard. Under this burden, English calico-printing could not be expected to make a rapid progress. Accordingly, even so lately as the year 1750, no more than 50,000 pieces of mixed stuff were printed in Great Britain, and that chiefly in the neighborhood of London; whereas a single manufacturer, Mr. Coates of Manchester, now-a-days will turn off nearly twenty times that quantity, and there are very many others who manufacture several hundred thousand pieces per annum. It was not till about 1766 that this art migrated into Lancashire, where it has since taken such extraordinary development; but it was only after 1774 that it began to be founded upon right principles, in conse-quence of the repeal of that part of the act of 1730 which required the warp to be made of linen yarn. Henceforth the printer, though still saddled with a heavy duty of 3d. the square yard, was allowed to apply his colors to a homogeneous web, instead of the mixed fabric of linen and cotton substances, which differ in their affinities for dyes.

France pursued for some time a similar false policy with regard to calico-printing, but she emerged sooner from the mists of manufacturing monopoly than England. Her avowed motive was to cherish the manufacture of flax, a native product, instead of that of cotton, a raw material, for which prejudice urged that money had to be exported. Her intelligent statesmen of that day, fully seventy years ago, replied that the money expended in the purchase of cotton was the produce of French industry, beneficially employed, and they therefore took immediate measures to put the cotton fabrics upon a footing of equality. Meanwhile the popular prejudices became irritated to such a degree, by the project of permitting the free manufacture and sale of printed cottons, that every French town possessed of a chamber of commerce made the strongest remonstrances against it. The Rouen deputies declared to the government, " that the intended mea-sure would throw its inhabitants into despair, and make a desert of the surrounding country:" those of Lyons said, " the news had spread terror through all its workshops:" Tours " foresaw a commotion likely to convulse the body of the state:" Amiens said, " that the new law would be the grave of the manufacturing industry of France;" and Paris declared that " her merchants came forward to bathe the throne with their tears upon that inauspicious occasion."

The government persisted in carrying its truly enlightened principles into effect, and with so manifest advantage to the nation, as to warrant the inspector-general of manu-factures to make, soon afterwards, the following appeal to those prejudiced bodies:— "Will any of you now deny that the fabrication of printed cottons has occasioned a vast extension of the industry of France, by giving profitable employment to a great many

hands in spinning, weaving, bleaching, and printing the colors? Look only at the dyeing department, and say whether it has not done more good to France in a few years than many of your other manufactures have in a century?"

The despair of Rouen has been replaced by the most signal prosperity in the cotton trade, and especially in printed calicoes, for the manufacture of which it possesses 70 different establishments, producing upwards of a million of pieces of greater average size and price than the English. In the district of the Lower Seine, round that town, there are 500 cotton factories of different kinds, which give employment to 118,000 operatives of all orders, and thus procure a comfortable livelihood to probably not less than half a million of people.

The repeal, in 1831, of the consolidated duty of 3½d. per square yard upon printed calicoes in Great Britain is one of the most judicious acts of modern legislation. By the improvements in calico-printing, due to the modern discoveries and inventions in chemistry and mechanics, the trade had become so vast as to yield in 1830 a revenue of 2,280,000l. levied upon 8,596,000 pieces, of which, however, about three fourths were exported, with a drawback of 1,579,000l. 2,281,512 pieces were consumed in that year at home. When the expenses of collection were deducted, only 350,000l. found their way into the exchequer, for which pitiful sum thousands of frauds and obstructions were committed against the honest manufacturer. This reduction of duty enables the consumer to get this extensive article of clothing from 50 to 80 per cent. cheaper than before, and thus places a becoming dress within the reach of thousands of handsome females in the humbler ranks of life. Printed goods, which in 1795 were sold for two shillings and three-pence the yard, may be bought at present for eight-pence. In fact, a woman may now purchase the materials of a pretty gown for two shillings. The repeal of the tax has been no less beneficial to the fair dealers, by putting an end to the contraband trade, formerly pursued to an extent equally injurious to them and the revenue. It has, moreover, emancipated a manufacture, eminently dependant upon taste, science, and dexterity, from the venal curiosity of petty excisemen, by whom private improvements, of great value to the inventor, were in perpetual jeopardy of being pirated and sold to any sordid rival. The manufacturer has now become a free agent, a master of his time, his workmen, and his apparatus; and can print at whatever hour he may receive an order; whereas he was formerly obliged to wait the convenience of the excise officer, whose province it was to measure and stamp the cloth before it could be packed, —an operation fraught with no little annoyance and delay. Under the patronage of parliament, it was easy for needy adventurers to buy printed calicoes, because they could raise such a sum by drawbacks upon the export of one lot as would go far to pay for another, and thus carry on a fraudulent system of credit, which sooner or later merged in a disastrous bankruptcy. Meanwhile the goods thus obtained were pushed off to some foreign markets, for which they were possibly not suited, or where they produced, by their forced sales, a depreciation of all similar merchandise, ruinous to the man who meant to pay for his wares.

The principles of calico-printing have been very profoundly studied by many of the French manufacturers, who generally keep a chemist, who has been educated in the Parisian schools of science, constantly at work, making experiments upon colors in a well-mounted laboratory. In that belonging to M. Daniel Kœchlin, of Mulhausen, there are upwards of 3000 labelled vials, filled with chemical reagents, and specimens subservient to dyeing. The great disadvantage under which the French printers labor is the higher price they pay for cotton fabrics above that paid by the English printers. It is this circumstance alone which prevents them from becoming very formidable rivals to us in the markets of the world. M. Barbet, deputy and mayor of Rouen, in his replies to the ministerial commission of inquiry, rates the disadvantage proceeding from that cause at 2 francs per piece, or about 5 per cent. in value. In the annual report of the *Société Industrielle* of Mulhausen, made in December, 1833, the number of pieces printed that year in Alsace is rated at 720,000, to which if we add 1,000,000 for the produce of the department of the Lower Seine, and 280,000 for that of St. Quentin, Lille, and the rest of France, we shall have for the total amount of this manufacture 2,000,000 of pieces, equivalent to nearly 2,400,000 pieces English; for the French piece usually measures 33¼ aunes, = 41 yards nearly; and it is also considerably broader than the English pieces upon an average. It is therefore probable that the home consumption of France in printed goods is equal in quantity, and superior in value, to that of England. With regard to the comparative skill of the workmen in the two countries, M. Nicholas Kœchlin, deputy of the Upper Rhine, says, that one of his foremen, who worked for a year in a printfield in Lancashire, found little or no difference between them in that respect. These English wages are considerably higher than the French. The machines for multiplying production, which for some time gave us a decided advantage, are now getting into very general use among our neighbors. In my recent visit to Mulhausen, Rouen, and their environs, I had an opportunity of seeing many printing establishments mounted with all the resources of the most refined mechanisms.

The calico-printing of this country still labors under the burden of considerable taxes upon madder and gallipoli oil, which have counteracted the prosperity of our Turkey red styles of work, and caused them to flourish at Elberfeldt, and some other places on the continent whither a good deal of the English yarns are sent to be dyed, then brought back, and manufactured into ginghams, checks, &c., or forwarded directly thence to our Russian customers. This fact places our fiscal laws in the same odious light as the facility of pirating printers' patterns with impunity does our chancery laws.

Before cloth can receive good figured impressions its surface must be freed from fibrous down by SINGEING, and be rendered smooth by the CALENDER. See these articles. They are next bleached, with the exception of those destined for Turkey red. See BLEACHING and MADDER. After they are bleached, dried, singed, and calendered, they are lapped round in great lengths of several pieces, stitched endwise together, by means of an apparatus called in Manchester a *candroy*, which bears on its front edge a rounded iron bar, transversely grooved to the right and left from the centre, so as to spread out the web as it is drawn over it by the rotation of the lapping roller. See a figure of this bar subservient to the cylinder printing-machine.

Four different methods are in use for imprinting figures upon calicoes: the first is by small wooden blocks, on whose face the design is cut, which are worked by hand; the second is by larger wood-cut blocks, placed in either two or three planes, standing at right angles to each other, called a Perrotine, from the name of its inventor; the third is by flat copper plates, a method now almost obsolete; and the fourth is by a system of copper cylinders, mounted in a frame of great elegance, but no little complexity, by which two, three, four, or even five colors may be printed on in rapid succession by the mere rotation of the machine driven by the agency of steam or water. The productive powers of this printing automaton are very great, amounting for some styles to a piece in the minute, or a mile of cloth in the hour. The fifth color is commonly communicated by means of what is called a surface cylinder, covered with wooden figures in bass-relief, which, by rotation, are applied to a plane of cloth imbued with the thickened mordants.

The hand blocks are made of sycamore or pear-tree wood, or of deal faced with these woods, and are from two to three inches thick, nine or ten inches long, and five broad, with a strong box handle on the back for seizing them by. The face of the block is either carved in relief into the desired design, like an ordinary wood-cut, or the figure is formed by the insertion edgewise into the wood of narrow slips of flattened copper wire. These tiny fillets, being filed level on the one edge, are cut or bent into the proper shape, and forced into the wood by the taps of a hammer at the traced lines of the configuration. Their upper surfaces are now filed flat, and polished into one horizontal plane, for the sake of equality of impression. As the slips are of equal thickness in their whole depth, from having been made by running the wire through between the steel cylinders of a flatting mill, the lines of the figure, however much they get worn by use, are always equally broad as at first; an advantage which does not belong to wood-cutting. The interstices between the ridges thus formed are filled up with felt-stuff. Sometimes a delicate part of the design is made by the wood-cutter, and the rest by the insertion of copper slips.

The coloring matter, properly thickened, is spread with a flat brush, by a child, upon fine woollen cloth, stretched in a frame over the wax cloth head of a wooden drum or sieve, which floats inverted in a tubful of old paste, to give it elastic buoyancy. The inverted sieve drum should fit the paste tub pretty closely. The printer presses the face of the block on the drum head, so as to take up the requisite quantity of color, applies it to the surface of the calico, extended upon a flat table covered with a blanket, and then strikes the back of the block with a wooden mallet, in order to transfer the impression fully to the cloth. This is a delicate operation, requiring equal dexterity and diligence. To print a piece of cloth 25 yards long, and 30 inches broad, no less than 672 applications of a block, 9 inches long and 5 inches broad, are requisite for each color; so that if there are three colors, or three hands as the French term it, no less than 2016 applications will be necessary. The blocks have pin-points fixed into their corners, by means of which they are adjusted to their positions upon the cloth, so as to join the different parts of the design with precision. Each printer has a color-tub placed within reach of his right hand; and for every different color he must have a separate sieve. Many manufacturers cause their blocks to be made of three layers of wood, two of them being deal with the grain crossed to prevent warping, and the third sycamore for engraving.

The printing shop is an oblong apartment, lighted with numerous windows at each side, and having a solid table opposite to each window. The table B, *fig.* 231, is formed of a strong plank of well-seasoned hard wood, mahogany, or marble, with a surface truly plane. Its length is about 6 feet, its breadth 2 feet, and its thickness 3, 4, or 5 inches. It stands on strong feet, with its top about 36 inches above the floor. At one of its ends there are two brackets c for supporting the axles of the roller E, which carries the

white calico to be printed. The hanging rollers E are laid across joists fixed near the roof of the apartment above the printing shop, the ceiling and floor between them being open bar work, at least in the middle of the room. Their use is to facilitate the exposure, and, consequently, the drying of the printed pieces, and to prevent one figure being daubed by another. Should they come to be all filled, the remainder of the goods must be folded lightly upon the stool D.
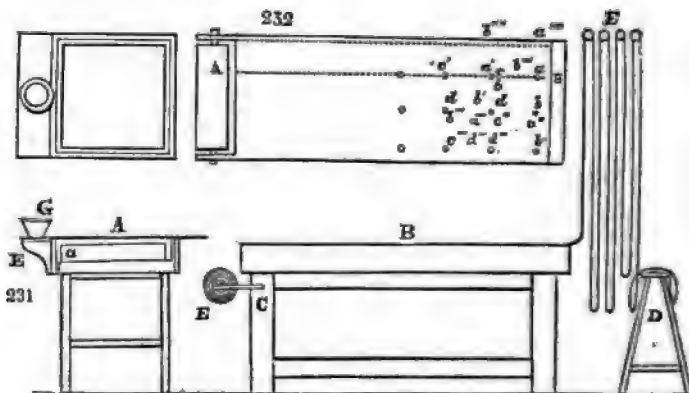
The printer stretches a length of the piece upon his table A B, taking care to place the selvage towards himself, and one inch from the edge. He presents the block towards the end, to determine the width of its impression, and marks this line A B, by means of his square and tracing point. The spreader now besmears the cloth with the color, at the commencement, upon both sides of the sieve head; because, if not uniformly applied, the block will take it up unequally. The printer seizes the block in his right hand, and daubs it twice in different directions upon the sieve cloth, then he transfers it to the calico in the line A B, as indicated by the four points *a b c d*, corresponding to the four pins in the corners of the block. Having done so, he takes another daub of the color, and makes the points *a b* fall on *c d*, so as to have at the second stamp *a' b'*, covering *a b* and *c' d'*; and so on, through the rest, as denoted by the accented letters. When one table length is finished, he draws the cloth along, so as to bring a new length in its place.

The grounding-in, or re-entering (*rentrage*), of the other colors is the next process. The blocks used for this purpose are furnished with pin-points, so adjusted that, when they are made to coincide with the pin-points of the former block, the design will be correct; that is to say, the new color will be applied in its due place upon the flower or other figure. The points should not be allowed to touch the white cloth, but should be made to fall upon the stem of a leaf, or some other dark spot. These *rentrages* are of four sorts :— 1. One for the mordants, as above ; 2. one for topical colors ; 3. one for the application of reds; and, 4. one for the application of resist pastes or reserves. These styles have superseded the old practice of pencilling.

The Perrotine is a machine for executing block-printing by mechanical power; and it performs as much work, it is said, as 20 expert hands. I have seen its operation, in many factories in France and Belgium, in a very satisfactory manner; but I have reason to believe that there are none of them as yet in this country. Three wooden blocks, from 2½ to 3 feet long, according to the breadth of the cloth, and from 2 to 5 inches broad, faced with pear-tree wood, engraved in relief, are mounted in a powerful cast-iron frame work, with their planes at right angles to each other, so that each of them may, in succession, be brought to bear upon the face, top, and back of a square prism of iron covered with cloth, and fitted to revolve upon an axis between the said blocks. The calico passes between the prism and the engraved blocks, and receives successive impressions from them as it is successively drawn through by a winding cylinder. The blocks are pressed against the calico through the agency of springs, which imitate the elastic pressure of the workman's hand. Each block receives a coat of colored paste from a woollen surface, smeared after every contact with a mechanical brush. One man, with one or two children for superintending the color-giving surfaces, can turn off about 30 pieces English per day, in three colors, which is the work of fully 20 men and 20 children in block printing by hand. It executes some styles of work to which the cylinder machine, without the surface roller, is inadequate.

The copper-plate printing of calico is almost exactly the same as that used for printing gravings on paper from flat plates, and being nearly superseded by the next machine, ed not be described.

The cylinder printing machine consists, as its name imports, of an engraved copper linder, so mounted as to revolve against another cylinder lapped in woollen cloth, and ibued with a colored paste, from which it derives the means of communicating colored impressions to pieces of calico passed over it. *Fig.* 223 will give the reader a general idea of this elegant and expeditious plan of printing. The pattern is engraved upon the surface of a hollow cylinder of copper, or sometimes gunmetal, and the cylinder is forced by pressure upon a strong iron mandrel, which serves as its turning shaft. To facilitate the transfer of the impression from the engraving to the cotton cloth, the latter is lapped round another large cylinder, rendered elastic by rolls of woollen cloth, and the engraved cylinder presses the calico against this elastic cushion, and thereby prints it as it revolves. Let A be the engraved cylinder mounted upon its mandrel, which receives rotatory motion by wheels on its end, connected with the steam or water power of the factory. B is a large iron drum or roller, turning in bearings of the end frames of the machine. Against that drum the engraved cylinder A is pressed by weights or screws; the weights acting steadily, levers, upon its brass bearings. Round the drum B the endless web of felt or blant stuff *a a*, travels in the direction of the arrow, being carried round along with the um B, which again is turned by the friction of contact with the cylinder A. c reprents a clothed wooden roller, partly plunged into the thickened color of the trough D D. at roller is also made to bear, with a moderate force, against A, and thus receives, by ction, in some cases, a movement of rotation. But it is preferable to drive the roller c un the cylinder A, by means of a system of toothed wheels attached to their ends, so that e surface speed of the wooden or paste roller shall be somewhat greater than that of e printing cylinder, whereby the color will be rubbed, as it were, into the engraved rts of the latter.

As the cylinder A is pressed upwards against B, it is obvious that the bearers of the ough and its roller must be attached to the bearings of the cylinder A, in order to eserve its contact with the color-roller c. *b* is a sharp-edged ruler of gun-metal or eel, called the *color doctor*, screwed between two gun-metal stiffening bars; the edge which wiper is slightly pressed as a tangent upon the engraved roller A. This ruler brates with a slow motion from side to side, or right to left, so as to exercise a delicate aving action upon the engraved surface, as this revolves in the direction of the arrow. is another similar sharp-edged ruler, called the *lint doctor*, whose office it is to remove y fibres which may have come off the calico in the act of printing, and which, if left i the engraved cylinder, would be apt to occupy some of the lines, or at least to prevent e color from filling them all. This *lint doctor* is pressed very slightly upon the cylinder , and has no transverse motion.

What was stated with regard to the bearers of the color trough D, namely, that they re connected, and moved up and down together with the bearings of the cylinder A, may so be said of the bearers of the two doctors.

The working of this beautiful mechanism may now be easily comprehended. The reb of calico, indicated in the figure by the letter *d*, is introduced or carried in along ith the blanket stuff *a a*, in the direction of the arrow, and is moved onward by the ressure of the revolving cylinder A, so as to receive the impression of the pattern enraved on that cylinder.

Before proceeding to describe the more complex calico-machine which prints upon oth 3, 4, or 5 colors at one operation, by the rotation of so many cylinders, I shall xplain the modern methods of engraving the cylinder, which I am enabled to do by the urtesy of Mr. Locket, of Manchester, an artist of great ingenuity in this department, who olitely allowed me to inspect the admirable apparatus and arrangements of his factory.

To engrave a copper cylinder 3 or 4 inches in diameter, and from 30 to 36 inches long, with the multitude of minute figures which exist in many patterns, would be a very laborious and expensive operation. The happy invention made by Mr. Jacob Perkins, in America, for transferring engravings from one surface to another by means of steel roller dies, was with great judgment applied by Mr. Locket to calico-printing, so long ago as the year 1808, before the first inventor came to Europe with the plan. The pattern is first drawn upon a scale of about 3 inches square, so that this size of figure being repeated a definite number of times, will cover the cylinder. This pattern is next engraved in intaglio upon a roller of softened steel, about 1 inch in diameter, and 3 inches long, so that it will exactly occupy its surface. The engraver aids his eye with a

lens, when employed at this delicate work. This roller is hardened by heating it to a cherry-red in an iron case containing pounded bone-ash, and then plunging it into cold water; its surface being protected from oxydizement by a chalky paste. This hardened roller is put into a press of a peculiar construction, where, by a rotatory pressure, it transfers its design to a similar roller in the soft state; and as the former was in intaglio, the latter must be in relievo. This second roller being hardened, and placed in an appropriate volutory press, is employed to engrave by indentation upon the full-sized copper cylinder the whole of its intended pattern. The first roller engraved by hand is called the *die*; the second, obtained from it by a process like that of a milling tool, is called the *mill*. By this indentation and multiplication system, an engraved cylinder may be had for seven pounds, which engraved by hand would cost fifty or upwards. The restoration of a worn-out cylinder becomes extremely easy in this way; the mill being preserved, need merely be properly rolled over the copper surface again.

At other times, the hard roller *die* is placed in the upper bed of a screw press, not unlike that for coining, while the horizontal bed below is made to move upon strong rollers mounted in a rectangular iron frame. In the middle of that bed a smooth cake or flat disc of very soft iron, about 1 inch thick, and 3 or 4 inches in diameter, is made fast by four horizontal adjusting screws, that work in studs of the bed frame. The *die* being now brought down by a powerful screw, worked by toothed wheel-work, and made to press with force upon the iron cake, the bed is moved backwards and forwards, causing the roller to revolve on its axles by friction, and to impart its design to the cake. This iron disc is now case-hardened by being ignited amidst horn shavings in a box, and then suddenly quenched in water, when it becomes itself a die in relievo. This disc die is fixed in the upper part of a screw press with its engraved face downwards, yet so as to be moveable horizontally by traverse screws. Beneath this inverted bed, sustained at its upper surface by friction-rollers, a copper cylinder 30 inches long, or thereby, is mounted horizontally upon a strong iron mandrel, furnished with toothed wheels at one of its ends, to communicate to it a movement upon its axis through any aliquot arcs of the circle. The disc die being now brought down to bear upon the copper cylinder, this is turned round through an arc corresponding in length to the length of the die; and thus, by the steady downward pressure of the screw, combined with the revolution of the cylinder, the transfer of the engraving is made in intaglio. This is, I believe, the most convenient process for engraving, by transfer, the copper of a one-cylinder machine. But when 2, 3, or 4 cylinders are to be engraved with the same pattern for a two, three, or four-colored machine, the die and the mill roller plan of transfer is adopted. In this case, the hardened roller die is mounted in the upper bed of the transfer press, in such a way as to be capable of rotation round its axis, and a similar roller of softened steel is similarly placed in the under bed. The rollers are now made to bear on each other by the action of the upper screw, and while in hard contact, the lower one is caused to revolve, which, carrying round the upper by friction, receives from it the figured impression in relief. When cylinders for a three-colored machine are wanted, three such *mills* are made fac-similes of each other; and the prominent parts of the figure which belong to the other two copper cylinders are filed off in each one respectively. Thus three differently figured *mills* are very readily formed, each adapted to engrave its particular figure upon a distinct copper cylinder.

Some copper cylinders for peculiar styles are not graved by indentation, as just described, but etched by a diamond point, which is moved by mechanism in the most curious variety of configurations, while the cylinder slowly revolves in a horizontal line beneath it. The result is extremely beautiful, but it would require a very elaborate set of drawings to represent the machinery by which Mr. Locket produces it. The copper is covered by a resist varnish while being heated by the transmission of steam through its axis. After being etched, it is suspended horizontally by the ends, for about five minutes, in an oblong trough charged with dilute nitric acid.

With regard to the two and three-colored machines, we must observe, that as the calico in passing between the cylinders is stretched laterally from the central line of the web, the figures engraved upon the cylinders must be proportionally shortened, in their lateral dimensions especially, for the first and second cylinder.

Cylinder printing, though a Scotch invention, has received its wonderful development in England, and does the greatest honor to this country. The economy of labor introduced by these machines is truly marvellous; one of them, under the guidance of a man to regulate the rollers, and the service of a boy, to supply the color troughs, being capable of printing as many pieces as nearly 200 men and boys could do with blocks. The perfection of the engraving is most honorable to our artisans. The French, with all their ingenuity and neat-handedness, can produce nothing approaching in excellence to the engraved cylinders of Manchester,—a painful admission, universally made to me by every eminent manufacturer in Alsace, whom I visited in my late tour.

Another modification of cylinder printing, is that with wooden rollers cut in relief; it is called *surface printing*, probably because the thickened color is applied to a tense surface of woollen cloth, from which the roller takes it up by revolving in contact with the cloth. When the copper cylinders and the wooden ones are combined in one apparatus, it has got the appropriate name of the *union* printing machine.

In mounting three or more cylinders in one frame, many more adjustments become necessary than those described above. The first and most important is that which ensures the correspondence between the parts of the figures in the successive printing rollers, for unless those of the second and subsequent engraved cylinders be accurately inserted into their respective places, a confused pattern would be produced upon the cloth as it advances round the pressure cylinder B, *figs.* 233, 234.

Each cylinder must have a forward adjustment in the direction of rotation round its axis, so as to bring the patterns into correspondence with each other in the length of the piece; and also a lateral or traverse adjustment in the line of its axis, to effect the correspondence of the figures across the piece; and thus, by both together, each cylinder may be made to work symmetrically with its fellows.

Fig. 234 is a cross section of a four-color cylinder machine, by which the working parts are clearly illustrated.

A A A is a part of the two strong iron frames or cheeks, in which the various rollers are mounted. They are bound together by the rods and bolts *a a a a*.

B is the large iron pressure cylinder, which rests with its gudgeons in bearings or bushes, which can be shifted up and down in slots of the side cheeks A A. These bushes are suspended from powerful screws *b*, which turn in brass nuts, made fast to the top of the frame A, as is plainly shown in the figure. These screws serve to counteract the strong pressure applied beneath that cylinder, by the engraved cylinders D E.

C D E F are the four printing cylinders, named in the order of their operation. They consist of strong tubes of copper or gun-metal, forcibly thrust by a screw press upon the iron mandrels, round which as shafts they revolve.

The first and last cylinder C and F are mounted in brass bearings, which may be shifted in horizontal slots of the frame A. The pressure roller B, against whose surface they bear with a very little obliquity downwards, may be nicely adjusted to that pressure by its elevating and depressing screws. By this means C and F can be adjusted to B with geometrical precision, and made to press it in truly opposite directions.

The bearings of the cylinders D and E are lodged also in slots of the frame A, which point obliquely upwards, towards the centre of B. The pressure of these two print cylinders C and F is produced by two screws *c* and *d*, which work in brass nuts, made fast to the frame and very visible in the figure. The frame-work in which these bearings and screws are placed, has a curvilinear form, in order to permit the cylinders to be readily removed and replaced; and also to introduce a certain degree of elasticity. Hence the pressure applied to the cylinders C and F, partakes of the nature of a spring; a circumstance essential to their working smoothly, on account of the occasional inequalities in the thickness of the felt web and the calico.

The pressure upon the other two print cylinders D and E is produced by weights acting with levers against the bearings. The bearings of D are, at each of their ends, acted upon by cylindrical rods, which slide in long tubular bosses of the frame, and press with their nuts *g* at their under end upon the small arms of two strong levers G, which lie on each side of the machine, and whose fulcrum is at *h* (in the lower corner at the left hand). The long arms of these levers G, are loaded with weights H, whereby they are made to press up against the bearings of the roller D, with any degree of force, by screwing up the nut *g*, and hanging on the requisite weights.

The manner in which the cylinder F is pressed up against B, is by a similar construction to that just described. With each of its bearings, there is connected by the link *k*, a curved lever I, whose fulcrum or centre of motion is at the bolt *l*. To the outer end of this lever, a screw, *m*, is attached, which presses downwards upon the link *n*, connected with the small arm of the strong lever K, whose centre of motion is at *o*. By turning therefore the screw *m*, the weight L, laid upon the end of the long arm of the lever K (of which there is one upon each side of the machine), may be made to act or not at pleasure upon the bearings of the cylinder E.

In tracing the operation of this exquisite printing machine, we shall begin with the first engraved cylinder C. Its bearings or bushes shift, as was already stated, in slots of the frame A. Each of them consists of a round piece of iron, to which the end of the screw *c* is joined, in the same way as at *d*, in the opposite side. In each of these iron bearings, a concave brass is inserted to support the collar of the shaft, and in a dovetailed slit of this brass, a sliding piece is fitted, upon which a set or adjusting screw in the iron bearing acts, and which, being forced against the copper cylinder C, serves to adjust the line of its axis, and to keep it steady between its bearings, and true in its rotatory motion. Upon the iron bearing a plate is screwed, provided with two flanges,

which support the color trough q, and the color roller M. This trough, as well as the others to be mentioned presently, is made of sheet copper in the sides and bottom, and

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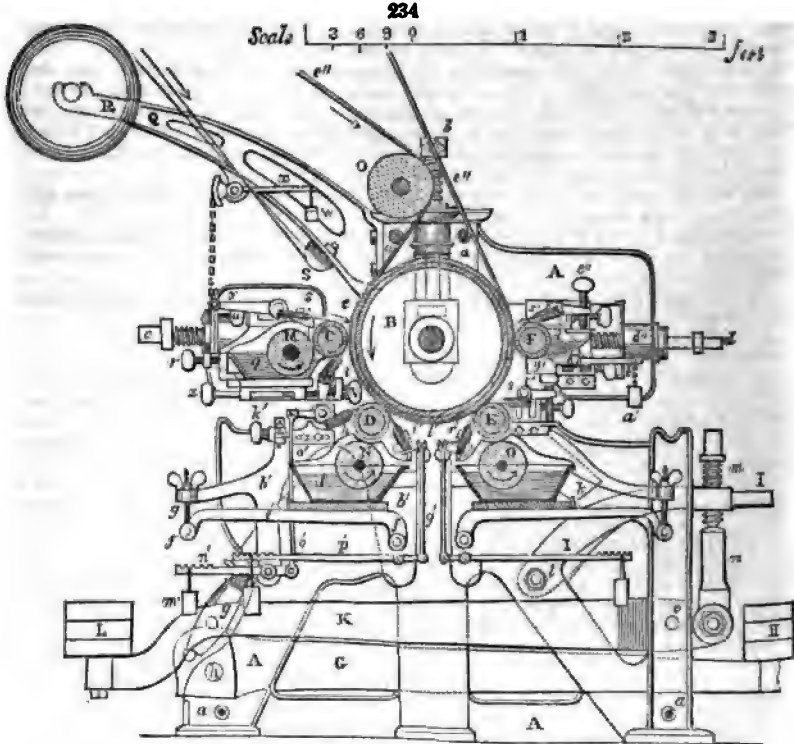
fixed upon a board; but its ends are made of plates of cast copper or gun-metal to serve as bearings to the color roller M. The trough and its roller may be shifted both together into contact with the printing cylinder c, by means of the screw r. Near s, seen above the roller, c, and t below it, are sections of the two doctors, which keep the engraved cylinders in sound working condition; the former being the colour doctor, and the latter the lint doctor. Their ends lie in brasses, which may be adjusted by the screws u and v, working in the respective brackets, which carry their brasses, and are made fast to the iron bearings of the cylinder.

The pressure of the color doctor is produced by two weights w, (see high up on the frame work,) which act on a pair of small levers x, (one on each side of the machine,) and thus, by means of the chains, tend to lift the arms y, attached to the end axles of the doctor. The pressure of the lint doctor upon the cylinder c, is performed by the screw z, pressing upon an arm which projects downwards, and is attached to the axle of that doctor.

The bearings of the second printing cylinder D, consist at each end of a mass of iron (removed in the drawing to show the mechanism below it), which shifts in the slanting slot of the frame A. In each of these masses there is another piece of iron, which slides in the transverse direction, and may be shifted by the adjusting screw a' fixed to it, and working in a nut cast upon the principal bearing above described. To the inner bearings, which carry the brasses in which the shaft lies, are screwed the two curved arms b' b' to which are attached the bearings &c., for the color trough and the doctors. In these brasses there are also dovetailed pieces, which slide and are pressed by set screws furnished with square heads in the iron secondary bearings, which serve, as before said, to adjust the printing cylinder in the line of its axis, while other screws adjust the distance of the cloth upon which the second color is printed, and the line of contact with the cylinder B.

N, is the color roller of D, and d' the color trough, which rests by its board upon the lever e'; whose centres of motion f', are made fast to the curved arms b', fixed at the

earings of the cylinder, and whose ends are suspended by screws g'; whereby the color roller N, may be pressed with greater or less force to the cylinder D. h' and i' are the two doctors of this cylinder; the former being the color, the latter the lint doctor. They rest, as was said of the cylinder c, in brasses which are adjustable by means of screws, that work in the studs or brackets by which the brasses are supported. These brackets must of course be screwed to the secondary bearing-pieces, in order that they may keep their position, into whatever direction the bearings may be shifted. k' and l' are these set screws for the color and lint doctors. The pressure of the former upon the cylinder D, is produced by weights m', acting upon levers n', and pressing by rods or links l', upon arms attached to each end of the axis of the doctor. (See the left hand side of the figure near the bottom.) The lint-doctor i' is pressed in a similar way at the other side upon the cylinder D, by the weights acting upon levers p', and by rods q' upon arms fixed at each end of the axis of the doctor.

The bearings of the third printing cylinder E, are of exactly the same construction as that above described, and therefore require no particular detail. The lint doctor s, is here pressed upon the engraved cylinder by screws t', working in the ends of studs or arms fixed upon each end of the axis of the doctor, and pressing upon flanges cast upon the brackets in which the brasses of the doctor's axis lie, which are made fast to the bearings of the cylinder E.

The bearings of the fourth copper cylinder F, are also constructed in a similar way, each consists of a first bearing, to which is joined the end of the screw d, by which it is made to slide in a slot of the frame. Another bearing, which contains the brass for the shaft of the cylinder, can be shifted up and down in a transverse direction by a screw f, of the second bearing, working in a nut cast upon the first bearing. To this secondary bearing, plates are made fast by the screws v' v' to the inside, to carry the studs or brackets of the doctors x and y'. In the brasses of the cylinder shaft, dovetailed pieces are made to slide, being pressed by set screws w', against the engraved cylinder F, similar to what has been described for adjusting the cylinders to one another. This cylinder has no separate color roller, nor trough, properly speaking, but the color doctor y' is made concave to serve the purpose of a trough in supplying the engraved lines of the cylinder with color. With this view the top plate of the doctor is curved to contain the colored paste, and it is shut up at the ends by pieces of wood made to fit the curvature of the doctor. Its pressure against the engraved surface is produced by weights a'', acting at the ends of arms b'', attached to the ends of the axis of the doctor. The pressure of the lint doctor x' is given by screws c'', working in arms attached to the ends of the axis of the doctor, and pressing upon the flanges d'', cast upon the brackets which carry the brasses of the axis of the doctor. These brasses are themselves adjustable, like those of all the other cylinders, by set screws in the brackets, which work in the nuts formed in the brasses.

e'' e'', is the endless web of felt stuff which goes round the cylinder B, and constitutes the soft elastic surface upon which the printing cylinders c, D, E, and F exercise their pressure. This endless felt is passed over a set of rollers at a certain distance from the machine, to give opportunity for the drying up of any coloring paste which it may have imbibed from the calico in the course of the impressions. In its return to the machine in the direction of the arrow, it is led over a guide roller o, which is thereby made to revolve. Upon the two ends of this, and outside of the bearings which are fixed upon the tops of the frame A, are two eccentrics, one of which serves to give a vibratory traverse movement to the color doctors s', h', and r' of the three cylinders, c, D, and E, whilst the other causes the color doctor y' of the cylinder F, to make lateral vibrations.

Q is one of a pair of cast-iron brackets, screwed on at the back of the side-frames or cheeks A A, to carry the roller filled with white calico R, ready for the printing operations. Upon the end of the shaft whereon the calico is coiled, a pulley is fixed, over which a rope passes suspending a weight in order to produce friction, and thereby resistance to the action which tends to unwind the calico. In winding it upon that and similar rollers, the calico is smoothed and expanded in breadth by being passed over one or more grooved rods, or over a wooden bar s, fig. 235, the surface of which is covered with wire, so as to have the appearance of a united right and left-handed screw. By this device, the calico, folded or creased at any part, is stretched laterally from the centre, and made level. It then passes over the guide-roller t, where it comes upon the surface of the felt e'' e'', and thence proceeds under its guidance to the series of printing cylinders.

Three and four-color machines, similar to the above, are now at work in many establishments in Lancashire, which will turn off a piece of 28 yards per minute, each of the three or four cylinders applying its peculiar part of the pattern to the cloth as it passes along, by ceaseless rotation of the unwearied wheels. At this rate, the astonishing

length of one mile of many-colored web is printed with elegant flowers and other figures in an hour. When we call to mind how much knowledge and skill are involved in this process, we may fairly consider it as the greatest achievement of chemical and mechanical science.

Before entering upon the different styles of work which constitute calico-printing, I shall treat, in the first place, of what is common to them all, namely, the thickening of the mordants and colors. This is an operation of the greatest importance towards the successful practice of the art. Several circumstances may require the consistence of the thickening to be varied; such as the nature of the mordant, its density, and its acidity. A strong acid mordant cannot be easily thickened with starch; but it may be by roasted starch, vulgarly called British gum, and by gum arabic or senegal. Some mordants which seem sufficiently inspissated with starch, liquefy in the course of a few days, and, being apt to run in the printing-on, make blotted work. In France, this evil is readily obviated by adding one ounce of spirits of wine to half a gallon of color—a remedy which the English excise duties render too costly.

The very same mordant, when inspissated to different degrees, produces different tints in the dye-copper—a difference due to the increased bulk from the thickening substance; thus, the same mordant, thickened with starch, furnishes a darker shade than when thickened with gum. Yet there are circumstances in which the latter is preferred, because it communicates more transparency to the dyes, and because, in spite of the washing, more or less of the starch always sticks to the mordant. The gum has the inconvenience, however, of drying too speedily, and of also increasing too much the volume of the mordants; by both of which causes it obstructs their combination with the stuff, and the tints become thin or scratchy.

The substances generally employed as thickeners are the following:—

    1. Wheat starch.
    2. Flour.
    3. Roasted starch.
    4. Gum senegal.
    5. Gum tragacanth.
    6. Salep.
    7. Pipe-clay, mixed with gum senegal.
    8. Sulphate of lead.
    9. Sugar.
   10. Molasses.
   11. Glue.

After thickening with gum, we ought to avoid adding metallic solutions in the liquid state; such as nitrate of iron, of copper, solutions of tin, of subacetate of lead, &c.; as they possess the property of coagulating gum. I shall take care to specify the nature and proportion of thickening to be employed for each color; a most important matter, hitherto neglected by English writers upon calico-printing.

The atmosphere of the printing shops should never be allowed to cool under 65° or 70° F.; and it should be heated by proper stoves in cold weather, but not rendered too dry. The temperature and moisture should therefore both be regulated with the aid of thermometers and hydrometers, as they exercise a great influence upon all the printing processes, and especially upon the combination of the mordant with the cloth. In the course of the desiccation, a portion of the acetic acid evaporates with the water, and subacetates are formed, which combine with the stuff in proportion as the solvent principle escapes; the water, as it evaporates, carries off acetic acid with it, and thereby aids the fixation of bases. These remarks are peculiarly appropriate to delicate impressions by the cylinder machine, where the printing and drying are both rapidly effected. In the lapis lazuli style, the strong mordants are apt to produce patches, being thickened with pipe-clay and gum, which obstruct the evaporation of the acids. They are therefore apt to remain, and to dissolve a portion of the mordants at their immersion in the blue vat, or at any rate in the dung bath. In such a case, a hot and humid air is indispensable, after the application of the mordants, and sometimes the stuffs so impregnated must be suspended in a damp chamber. To prevent the resist pastes becoming rapidly crusty, substances apparently useless are mixed with them, but which act beneficially by their hygrometric qualities, in retarding the desiccation. Oil also is sometimes added with that view.

It is often observed that goods printed upon the same day, and with the same mordant, exhibit inequalities in their tints. Sometimes the color is strong and decided in one part of the piece, while it is dull and meager in another. The latter has been printed in too dry an atmosphere. In such circumstances a neutral mordant answers best, especially if the goods be dried in a hot flue, through which humid vapors are in constant circulation.

In padding, where the whole surface of the calico is imbued with mordant, the drying

apartment or flue, in which a great many pieces are exposed at once, should be so constructed as to afford a ready outlet to the aqueous and acid exhalations. The cloth ought to be introduced into it in a distended state; because the acetic acid may accumulate in the foldings, and dissolve out the earthy or metallic base of the mordant, causing white and gray spots in such parts of the printed goods. Fans may be employed with great advantage, combined with HOT FLUES. (See this article.)

In the color laboratory, all the decoctions requisite for the print work should be ready prepared. They are best made by a steam heat, by means of copper boilers of a cylindric form, rounded at the bottom, and incased within a cast-iron cylinder, the steam being supplied to the space between the two vessels, and the dye-stuff and water being introduced into the interior one, which for some delicate purposes may be made of tin, or copper tinned inside. A range of such steam apparatus should be placed either along one of the side walls, or in the middle line of the laboratory. Proper tables, drawers, vials, with chemical reagents, measures, balances, &c., should also be provided. The most useful dye-extracts are the following :—

Decoction of logwood, of Brazil-wood, of Persian berries, of quercitron bark, of nutgalls, of old fustic, of archil or cutbear, of cochineal, of cochineal with ammonia, of catechu.

The following mordants should also be kept ready prepared :—

1. Aluminous mordant.
  Take 50 gallons of boiling water.
        100 lbs. of alum.
        10 lbs. of soda crystals.
        75 lbs. of acetate of lead.

The soda should be added slowly to the solution of the alum in the water, and when the effervescence is finished, the pulverized acetate of lead is put in and well stirred about till it be all dissolved and decomposed. During the cooling, the mixture should be raked up a few times, and then allowed to settle. The supernatant liquor is the mordant; it has a density of 11° or 11½° Baumé. It serves for reds and pinks, and enters into the composition of puce and lilach.

2. Aluminous mordant.
  Take 50 gallons of water.
        100 lbs. of alum.
        10 lbs. of soda crystals.
        100 lbs. of acetate of lead ;—operate as above directed.

The supernatant liquor here has a density of 12° Baumé; it is employed for lapis resists or reserves, and the cylinder printing of madder reds.

3. Aluminous mordant.
  Take 50 gallons of water.
        100 lbs of alum.
        6 lbs. of soda crystals.
        50 lbs. of acetate of lead ;—operate as above directed.

This mordant is employed for uniform yellow grounds.

4. Aluminous mordant.
  This is made by adding potash to a solution of alum, till its earth begins to be separated, then boiling the mixture to precipitate the subsulphate of alumina, which is to be strained upon a filter, and dissolved in acetic acid of moderate strength with the aid of heat. This mordant is very rich in alumina, and marks 20° B.

5. Aluminous mordant.
  Take 12¼ gallons of water.
        100 lbs. of alum.
        150 lbs. of liquid pyrolignite of lime at 11½° Baumé.

This mordant is made with heat like the first; after cooling, some alum crystallizes, and it marks only 12¼° B.

A mordant is made by solution of alum in potash, commonly called—

6. Aluminate of potash. The caustic ley is prepared by boiling together for an hour 100 gallons of water, 200 lbs. of potash, and 80 lbs. of quicklime; the mixture is then allowed to settle, the supernatant liquor is decanted, and evaporated till its density be 35° B. In 30 gallons of that ley at a boiling heat, 100 lbs. of ground alum are to be dissolved. On cooling, crystals of sulphate of potash separate. The clear liquor is to be decanted off, and the crystals being washed with a little water, this is to be added to the ley. About 53 gallons of mordant should be obtained.

Mordant for Black.

The pyrolignite of iron, called iron liquor in this country, is the only mordant used in calico-printing for black, violet, puce, and brown colors. The acetate of alumina, prepared from pyroligneous acid, is much used by the calico-printers under the name of red or yellow liquor, being employed for these dyes.

We may observe that a strong mordant, like No. 2, does not keep so well as one of mean density, such as No. 1. Too much mordant relatively to the demands of the work should therefore not be made at a time.

There are eight different styles of calico-printing, each requiring different methods of manipulation, and peculiar processes.

1. The madder style, to which the best chintses belong, in which the mordants are applied to the white cloth with many precautions, and the colors are afterwards brought up in the dye-bath. These constitute permanent prints.

2. The padding or *plaquage* style, in which the whole surface of the calico is imbued with a mordant, upon which afterwards different colored figures may be raised, by the topical application of other mordants joined to the action of the dye-bath.

3. The reserve style, where the white cloth is impressed with figures in resist paste, and is afterward subjected first to a cold dye, as the indigo vat, and then to a hot dye-bath, with the effect of producing white or colored spots upon a blue ground.

4. The discharge or *rongeant* style, in which thickened acidulous matter, either pure or mixed with mordants, is imprinted in certain points upon the cloth, which is afterwards padded with a dark-colored mordant, and then dyed, with the effect of showing bright figures on a darkish ground.

5. China blues; a style resembling blue stone-ware, which requires very peculiar treatment.

6. The decoloring or *enlevage* style; by the topical application of chlorine or chromic acid to dyed goods. This is sometimes called a discharge.

7. Steam colors; a style in which a mixture of dye extracts and mordants is topically applied to calico, while the chemical reaction which fixes the colors to the fibre is produced by steam.

8. Spirit colors; produced by a mixture of dye extracts, and solution of tin, vulgarly called spirit by dyers. These colors are brilliant but fugitive.

I. The madder style; called by some dip colors. The true chints patterns belong to it; they have from 5 to 7 colors, several of which are grounded-in after the first dye has been given in the madder bath.

In dyeing with madder, sumach, fustic, or quercitron, is sometimes added to the bath, in order to produce a variety of tints with the various mordants at one operation.

1. Suppose we wish to produce flowers or figures of any kind containing red, purple, and black colors, we may apply the three mordants at once, by the three-color cylinder machine, putting into the first trough acetate of alumina thickened; into the second, acetate of iron; and into the third, a mixture of the two; then drying in the air for a few days to fix the iron, dunging and dyeing up in a bath of madder and sumach. If we wish to procure the finest madder reds and pinks, besides the purple and black, we must apply at first only the acetate of alumina of two densities, by two cylinders, dry, dung, and dye up, in a madder bath. The mordants of iron liquor for the black, and of iron liquor mixed with the aluminous for purple, must be now grounded-in by blocks, taking care to insert these mordants into their precise spots: the goods being then dried with airing for several days, and next dunged, are dyed up in a bath of madder and sumach. They must be afterwards cleared by branning. See BRAN, DUNGING, and MADDER.

2. Suppose we wish to produce yellow with red, pink, purple, and black; in this case the second dye-bath should contain quercitron or fustic, and the spots intended to be yellow should receive the acetate of alumina mordant.

3. The mordant for a full red may be acetate of alumina, of spec. grav. 1·055, thickened with starch, and tinged with Brazil-wood; that for a pale red or pink, the same at spec. gravity 1·014, thickened with gum; that for a middling red, the same at spec. gravity 1·027, thickened with British gum; and for distinction's sake, it may be tinged yellow with Persian berries. The mordant for black is a pyroligneous acetate of iron, of specific gravity 1·04; for purple the same, diluted with six times its volume of water; for chocolate, that iron liquor mixed with acetate of alumina, in various proportions according to the shade wanted. Sumach is mixed with the madder for all these colors except for the purple. The quantity of madder required varies according to the body of color to be put upon the cloth, being from one pound per piece to three or even four. The goods must be entered when the copper is cool, be gradually heated during two or three hours, up to ebullition, and sometimes boiled for a quarter of an hour; the pieces being all the while turned with a wince from the one side of the copper to the other. (See WINCE.) They are then washed and boiled in bran and water for ten or fifteen minutes. When there is much white ground in the chints, they must be branned a second or even a third time, with alternate washing in the dash-wheel. To complete the purification of the white, they are spread upon the grass for a few days; or what is more expeditious, and equally good if delicately managed, they are winced for a few minutes in a weak solution of chloride of lime.

4. In the grounding-in for yellow, after madder reds, the aluminous mordant being

applied, &c., the piece is dyed, for about an hour, with one pound of quercitron bark, the infusion being gradually heated to 150° or 160°, but not higher.

5. A yellow is sometimes applied in chints work after the other colors are dyed, by means of a decoction of Persian berries mixed with the aluminous mordant, thickened with flour or gum, and printed-on with the block; the piece, when dry, is passed through a weak carbonated alkaline water, or lime water, then washed and dried for the market.

6. *Black mordant.*—Take half a gallon of acetate of iron, of spec. grav. 1·04, 4 ounces of starch, and 4 ounces of flour. The starch must first be moistened with the acetate, then the flour must be added, the rest of the acetate well mixed with both, and the whole made to boil over a brisk fire for five minutes, stirring meanwhile to prevent adhesion to the bottom of the pot. The color must be poured into an earthen pipkin, and well mixed with half an ounce of gallipoli oil. In general, all the mordants, thickened with starch and flour, must be boiled for a few minutes. With British gum or common gum, they must be heated to 160° F., or thereby, for the purpose merely of dissolving them. The latter should be passed through a sieve to separate the impurities often present in common gum.

7. *Puce mordant.*—Take a quart of acetate of alumina and acetate of iron, each of spec. grav. 1·04, mixed and thickened like the black, No. 6. To give the puce a reddish tinge, the acetate of alumina should have a specific gravity of 1·048, and the iron liquor only 1·007.

Red mordants are thickened with British gum, and are sufficiently colored with the addition of any tinging decoction.

8. *Violet mordants.*—These consist either of a very weak solution of acetate of iron, of specific gravity 1·007, for example; or of a little of the stronger acetate of 1·04, mixed with acetate of alumina, and a little acetate of copper, thickened with starch or British gum. The shades may be indefinitely varied by varying the proportions of the acetates.

When black is one of the colors wanted, its mordant is very commonly printed-on first, and the goods are then hung upon poles in the drying-room, where they are aired for a few days, in order to fix the iron by its peroxydizement; the mordants for red, violet, &c., are then grounded in, and the pieces are dyed up, after dunging and washing, in the madder bath, into which, for certain shades, sumach, galls, or fustic is added. The goods are brightened with a boil in soap water; occasionally also in a bath, containing a small quantity of solution of tin or common salt. The following mode of brightening is much extolled by the French, who are famous for their reds and roses.

1. A soap boil of forty minutes, at the rate of 1 pound for every 2 pieces. Rinse in clear water.

2. Pass through chloride of soda solution of such strength that two parts of it decolor one part of Gay Lussac's test liquor. See CHLORIDE OF LIME and INDIGO. Wince the pieces through it for 40 minutes. Rinse again.

3. Pass it again through the soap bath, No. 1.

4. Brighten it in a large bath of boiling water, containing 4 pounds of soap, and 1 pound of a cream-consistenced salt of tin, containing nearly half its weight of the muriate of tin, combined with as much nitric acid of spec. grav. 1·288. This strong nitro-muriate having been diluted with a little water, is to be slowly poured into the bath of soap water, and well mixed by stirring. The pieces are now put in, and winced through it for one half or three quarters of an hour.

5. Repeat the soap boil, No. 1. Rinse and dry.

9. *Grounding-in of Indigo blue.*

Take half a gallon of water of 120° F., 8 ounces of ground indigo, and 8 ounces of red sulphuret of arsenic (orpiment), 8 ounces of quicklime, mix together, and heat the mixture to the boiling point; withdraw from the fire, and add, when it is lukewarm, 4 ounces of carbonate of soda, stir and leave the whole at rest till the next day. Then decant the clear liquor, and thicken every quart of it with half a pound of gum. This color ought to be green, and be preserved in a close vessel. When used, it is put into a pot with a narrow orifice, the pencil is dipped into it, wiped on the edge of the pot, and immediately applied by hand. This plan is tedious, and is nearly superseded by the following grounding blue.

Take half a gallon of caustic soda ley of spec. grav. 1·15, heated to 120° F.

12 ounces of hydrate of protoxyde of tin, obtained by precipitating it from the muriate of tin by solution of potash.

8 ounces of ground indigo; heat these mixed ingredients to the boiling point, then move the pot off and on the fire two or three times in succession, and finally thicken with 3 pounds of raw sugar. In order to apply this by the block, the following apparatus is employed, called the *canvass frame; figs.* 236, 237. It is formed of a copper
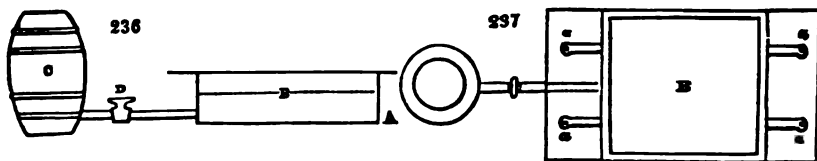
case or box A, in which is laid a frame B, filled with pretty stout canvass. The box communicates by a tube with the cistern c, mounted with a stop-cock D. *Fig.* 237 represents the apparatus in plan : A, the box; B, the canvass, with its edges *a a a a*, fixed by pin points to the sides. The color is *teared* (*tiré*), or spread even, with a wooden scraper as broad as the canvass. In working with this apparatus, the color being contained in the vessel c is drawn off into the case A, by opening the stop-cock D, till it rises to the level of the canvass. The instant before the printer daubs the block upon the canvass, the *tearer* (*tireur*), boy or girl, runs the scraper across it to renew its surface; and the printer immediately transfers the color to the cloth. In this kind of printing great skill is required to give evenly impressions. As the blue is usually applied to somewhat large designs, it is very apt to run; an inconvenience counteracted by dusting fine dry sand upon the cloth as soon as it is blocked. The goods must be washed within 24 hours after being printed.

10. *Topical grounding blue for the cylinder press.*

Take 3½ gallons of caustic soda ley of spec. grav. 1·15.

　　3½ lbs. of ground indigo.

　　5 lbs. of precipitated protoxyde of tin (as above).

Boil the mixed ingredients for ten minutes, take them from the fire, and add, first, 3 lbs. of Venice turpentine; then 11 lbs. of gum.

Put this mixture into the color trough, print with it, and after two days wash in the dash-wheel; then pass it through a soap-bath, along with a little soda, to brighten the blue, and to take off its grayish tint.

The use of the turpentine is easily explained: it serves to exclude the atmospherical oxygen, and prevent the regeneration of the indigo blue, before it is spread upon the cloth.

After the application to white calico of a similar blue, into which a little acid muriate of tin has been put, the goods are dipped for ten minutes in thin milk of lime, shaking the frame all the time. They are then washed, and cleared with a soap boil. The following color remains long in the deoxydized state from its containing 8 ounces of indigo, 10 ounces of hydrated protoxyde of tin, and 1½ pounds of solution of muriate of tin, to 2 quarts of soda ley of 1·15, thickened with 2¼ pounds of gum. This blue may be applied by either the block or the cylinder.

11. Topical Prussian blue for grounding.

2 quarts of water with 8 ounces of starch are to be mixed and boiled; add 2¼ ounces of a liquid Prussian blue color, prepared by triturating three quarters of an ounce of that pigment with as much muriatic acid, leaving the ingredients to react upon each other for 24 hours, and then adding three quarters of an ounce of water.

Add 4 ounces of liquid perchloride of tin (oxymuriate).

Mix all together, and pass through a searce. This color is not very fast; cloth printed with it will bear only rinsing.

12. Prussian blue figures are impressed as follows :—

Dissolve 8 ounces of sulphate of iron, and as much acetate of lead, separately in 2 quarts of boiling water; mix well, and settle. Take one quart of this clear liquor reduced to spec. grav. 1·02, one quart of mucilage containing 3 pounds of gum, colored with a little prussiate of potash, mix into a mordant, and print it on with the cylinder. Two days afterwards wash in tepid water containing a little chalk, and then pass the cloth through a solution of prussiate of potash in water, sharpened with a little muriatic acid till it takes the desired hue. Finally rinse.

II. The padding or *plaquage* style, called *foulard* also by the French. See PADDING.

Any mordant whatever, such as the acetates of alumina, or of iron, or their mixture, may be applied to the piece by the padding machine, after which it is dried in the HOT FLUE, washed, dunged, dyed, washed, and brightened.

Colors from metallic oxydes are very elegantly applied by the padding process. The the iron buff, the manganese bronze, and the chrome yellows and greens are given.

1. Iron buff or chamois.

Take 50 gallons of boiling water;

　　150 pounds of sulphate of iron; dissolve along with

　　10 pounds of alum; which partly saturate by the gradual addition of

　　5 pounds of crystals of soda; and in this mixture dissolve

50 pounds of pyroligneous acetate of lead. Allow the whole to settle, and draw off the clear supernatant liquid.

For furniture prints this bath should have the spec. grav. 1·07.

The calico being padded in it, is to be dried in the hot-flue; and after 48 hours suspension is to be washed in water at 170° containing some chalk, by the wince apparatus. It is then washed, by the same apparatus, in hot water, containing a pailful of soda ley of spec. grav. 1·04.

For light tints the padding liquor should be reduced to the spec. grav. 1·01. The dye in either case may be brightened by wincing through a weak solution of chloride of lime.

Nitrate of iron diffused through a body of water may be also used for padding, with alternate washings in water, and a final wincing in a weak alkaline ley.

With a stronger solution, similar to the first, the boot-top color is given.

2. The bronze or *solitaire*.

The goods are to be padded in a solution of the sulphate or muriate of manganese, of a strength proportional to the shade desired, dried in the hot-flue, and then raised by wincing them in a boiling-hot caustic ley, of spec. grav. 1·08, and next through a weak solution of chloride of lime, or soda. They are afterwards rinsed. Instead of passing them through the chloride, they may be merely exposed to the air till the manganese attracts oxygen, then rinsed and dried.

When the manganese solution has the density of 1·027, it gives a light shade; at the density of 1·06, a shade of moderate depth, and at 1·12 a dark tint.

The texture of the stuff is apt to be injured during the oxydation of the manganese.

3. *Carmelite* is obtained by padding in a mixture of muriate or sulphate of manganese and acetate of iron, then proceeding as above.

4. *Copper green* is given by padding in a mixed solution of sulphate and acetate of copper with a little glue, drying in the hot-flue, and next day padding in a caustic ley of spec. grav. 1·05. The goods are then rinsed, and padded through a solution made with 8 ounces of arsenious acid combined with 4 ounces of potash diluted with 2 gallons of water. They are finally rinsed and dried.

5. Olive and cinnamon colors are given by padding through mixed solutions of the acetate of iron and sulphate of copper; drying, and padding in a caustic ley of spec. grav. 1·05.

6. *Green and solitaire* form a pleasing umber, or hellebore shade, which may be obtained by padding through a mixed solution of manganese and aceto-sulphate of copper, and raising the shades as above prescribed.

7. *Chrome yellow.*

Pad in a solution of bichromate of potash containing 8 ounces of it to the gallon of water; then dry with moderate heat, and pad in a solution of acetate or nitrate of lead, containing 6 or 8 ounces in the gallon of water; wash, and dry. Or we may pad first in a solution of acetate of lead containing a little glue; dry, and pad in solution of bichromate of potash. Then rinse. The last process is apt to occasion cloudiness. To obtain a light lemon tint, we must pad in a solution of acetate of lead of double the above strength, or 16 ounces to the gallon, then wince the pieces through weak milk of lime, rinse, pad through bichromate of potash, rinse and dry.

8. *Chrome orange.*

Pad through a mixed solution of the subacetate and acetate of lead, three times in succession, and dry in the hot-flue; then wince for ten minutes through weak milk of lime: rinse; wince for a quarter of an hour in a warm solution of bichromate of potash; and finally raise the color by wincing the goods through hot lime-water.

9. *Prussian blue.*

Pad in the preceding chamois liquor of the spec. grav. 1·007; dry in the hot-flue; wince well in chalky water at 160° F., and then dye by wincing in the following liquor:—

Dissolve 5 ounces of prussiate of potash, in 25 gallons of water heated to 90° or 100°, adding 2 ounces of sulphuric acid; afterwards rinse, and brighten in a very dilute sulphuric acid.

10. *Green* is given by padding goods, previously dyed in the indigo vat, in a solution of acetate of lead containing a little glue; and then padding them in a warm solution of bichromate of potash; finally rinsing and drying.

III. Resist pastes or reserves; these are subservient to the cold indigo vat, and they may be distributed under four heads; 1. fat reserves; 2. reserves with bases of metallic salts; 3. colored reserves capable of assuming different tints in the dyeing; 4. reserves with mordants, for the cloth to be afterwards subjected to a dyeing bath, whereby variously colored figures are brought up on a blue ground, so as to resemble the mineral called *lazulite*; whence the name *lapis* or lapis lazuli.

1. The fatty resists are employed in the printing of silk; which see *infra*.

2. With regard to reserves the following general observations may be made. After printing-on the paste, the goods must be hung up in a chamber, rather humid than too dry, and left there for a certain time, more or less, according to the nature of the reserve. In dipping them into the blue vat, if the reserve be too dry, it is apt to swell, scale off, and vitiate the pattern. This accident is liable to happen also when the vat is deficient in lime, especially with deep blues.

1. *Simple white resist paste* for a full body of blue.

Take 1 gallon of water, in which are to be dissolved,

1 pound of binacetate of copper (distilled verdigris), and 3 lbs. of sulphate of copper.

This solution is to be thickened with

2 lbs. of gum senegal, 1 lb. of British gum, and 4 lbs. of pipe-clay; adding afterwards, 2 ounces of nitrate of copper—as a deliquescent substance.

2. *White reserve for light blues.*

Take 1 gallon of water, in which dissolve

4 ounces of binacetate of copper,

1 lb. of sulphate of copper; and thicken this solution with

2 lbs. of gum senegal, 1 lb. of British gum, and 4 lbs. of pipe-clay.

3. *White reserve for the cylinder machine.*

Take 1½ gallons of water; in which dissolve

2½ lbs. of binacetate of copper,

10 lbs. of sulphate of copper; and add to the solution

6 lbs. of acetate of lead; then thicken with

10 lbs. of gum; adding afterwards 10 lbs. of sulphate of lead.

After printing-on this reserve, the goods are to be hung up for two days, then dipped till the proper blue tint be obtained. Finally they must be winced through dilute sulphuric acid to clear up the white, by removing the cupreous tinge.

3. Colored reserves.

1. *Chamois reserve.*

Take 1 gallon of the chamois bath (No. 1, page 232, at bottom); to which add

8 ounces of nitrate of copper,

24 ditto of muriate of zinc; thicken with

6 pounds of pipe-clay, and 3 pounds of gum senegal.

After printing-on this paste, the goods must be hung up for five or six days in a somewhat damp room. Then after having dipped them in the vat, they are to be steeped in water for half an hour, and slightly washed. Next wince for half an hour, through water at 100° F. containing 2 pounds of soda crystals per 30 gallons. Rinse and dry.

2. *Chrome yellow reserve.*

Take 1 gallon of water; in which dissolve

3 lbs. of nitrate of lead,

1 lb. of binacetate of copper; to the solution, add

½ lb. of subacetate of lead; and thicken the mixed solution with

3 lbs. of gum.

6 lbs. of pipe-clay. Grind all the ingredients together, and pass through a searce.

After treating the goods as in No. 1, they must be winced for half an hour in a solution containing 5 ounces of bichromate of potash, per piece of calico, and also in a dilute muriatic bath, till the chrome yellow becomes sufficiently bright.

A chrome orange reserve may be made by introducing a larger proportion of subacetate of lead, and passing the reserve printed goods through weak milk of lime, as already prescribed for producing an orange by chrome.

The basis of the resist pastes used at Manchester is sometimes of more complex composition than the above; since, according to the private information I received from an extensive calico printer, they contain china clay (instead of pipe-clay, which often contains iron), strong solution of sulphate of copper, oil, tallow, and soap; the whole incorporated by trituration with heat.

In the Lancashire print-works, a little tartaric acid is added to the nitrate of lead, which prevents the color from taking a dingy cast.

4. *Reserves with mordants*, or the lazulite style.

1. *Black upon a blue ground.*

At Manchester the black pattern is printed-on with a mixture of iron liquor and extract of logwood, and the resist paste by the cylinder machine; in France the black is given by the following recipe:—

Take 1 gallon of decoction of galls of spec. grav. 1·04, mixed and boiled into a paste with

14 ounces of flour; into the paste, when nearly cold, there are added,

8 ounces of an acetated peroxyde of iron, made by adding 1 lb. acetate of lead to 3 lbs. of nitrate of iron, spec. grav. 1·56.

½ ounce of gallipoli oil.

This topical black forms a fast color, and resists the fine blue vat, weak potash ley, chromate of potash, boiling milk of lime, dunging, and maddering.

The preceding answers best for the block; the following for the cylinder,—

2. Take 1 gallon decoction of galls of spec. grav. 1·056.
    18 ounces of flour, mix, boil into a paste, to which, when cool, add
    8 ounces of the aceto-nitrate of iron of the preceding formula, and
    1 quart of iron liquor of spec. grav. 1·110.

In Lancashire a little prussiate of potash is sometimes added to nitrate of iron and coction of logwood; and the goods are after washing, &c. finished by passing through weak solution of bichromate of potash. The chromic acid gives depth and permanence the black dye, being supposed to impart oxygen to the iron, while it does not affect y of the other colors that may happen to be impressed upon the cloth, as solution of loride of lime would be apt to do. The solution of the bichromate deepens the spirit rples into blacks, and therefore with such delicate dyes becomes a very valuable application. This interesting fact was communicated to me by an eminent calico-printer in ıncashire.

Having premised the composition of the topical black dye, we are now prepared to ply it in the lazulite style.

1. *Black resist.*
ke 1 gallon of the above black without the flour,
    2 ounces of sulphate of copper,
    1 ounce of muriate of ammonia, dissolve and thicken with
    4 pounds of pipe-clay and 2 pounds of gum.
  Another good formula is the following :—
ke 1 gallon of iron liquor of 1·056 spec. grav.; dissolve in it,
    2 ounces of binacetate of copper,
    8 ounces of sulphate of copper; and thicken as just described.

2. *Puce reserve* paste, contains acetate of alumina mixed with the iron liquor.

3. *Full red reserve.*
ke 1 gallon of acetate of alumina, (made with 50 gallons water, 100 lbs. alum, 10 lbs. soda crystals, and 100 lbs. acetate of lead; the supernatant liquid being of spec. grav. 1·085;) dissolve in it
    4 ounces of corrosive sublimate; thicken with
    2 pounds of gum senegal,
    4 pounds of pipe-clay, and mix in 8 ounces of gallipoli oil.

4. *Reserve paste for a light red.*
ke 1 gallon of the weaker sulpho-acetate of alumina formerly prescribed; dissolve in it
    4 ounces of corrosive sublimate; and thicken with
    4 pounds of pipe-clay, and 2 pounds of gum; adding to the mixture
    8 ounces of oil.

5. *Neutral resist paste.*
ke 1 gallon of water; in which dissolve,
    3¼ lbs. of binarseniate of potash, and
    12 ounces of corrosive sublimate; thicken with
    3 lbs. of gum, and 6 lbs. of pipe-clay, adding to the paste 16 ounces of oil.

6. *Carmelite reserve paste.*
ke 1 half gallon of acetate of alumina, spec. grav. 1·014; (see second aluminous mordant, p. 230.)
    1 half gallon iron liquor of spec. grav. 1·027; dissolve in them
    4 ounces of sulphate of copper, 4 ounces of verdigris, and 1 ounce of nitrate of copper; thicken with
    2 lbs. of gum,
    4 lbs. of pipe-clay.

7. *Neutral reserve paste.*
ıke 1 gallon of water; dissolve in it,
    44 ounces of binarseniate of potash, and
    12 ounces of corrosive sublimate; thicken with
    3 lbs. of gum,
    6 lbs. of pipe-clay,
    16 oz. of oil.

To explain fully the manipulation of the lazulite style, we shall suppose that the calico are printed with the following reserves, taken in their order :—

           1. Black reserve,   No. 1. above.
           2. Full red reserve,   No. 3.
           3. Light red reserve, No. 4.
           4. Neutral reserve,   No. 7.

Four days after printing-on these reserves, the goods must be twice dipped in the blue

, ten minutes in and ten minutes out each time; but more dips may be given as
; to the desired depth of the shade. The cloth must be afterwards rinsed in ru
iter for half an hour. The next process is to remove the paste; which is done by
g the goods in a bran bath, lowered to 150°, during twenty minutes. They are
inced for five minutes in a bath of water slightly sharpened with vinegar. When
leansed they are ready for the madder bath. The *lapis* goods are finally cleared
ran bath, by exposure on the grass, and a soap boil.

The lazulite style is susceptible of many modifications.

8. *Deep blue ground*, with light blue, carmelite, and white figures.
1. Print-on *the white* reserve, No. 1.
2. Dip in the strongest blue vat; rinse and dry.
3. Ground-in with the block, the carmelite reserve (containing the mixed ace
of iron and alumina.)
4. Ground-in the neutral reserve.
5. Dip for the light blue; rinse.
6. Dung, dye, and clear, as above.

By varying the proportions of the reserve mordants, and the dye-stuffs, as ma
quercitron, &c. a great variety of effects may be produced.

9. *Deep green ground*, with buff and white figures.
1. Print-on the white reserve.
2. Dip in the blue vat; rinse and dry.
3. Pad in the buff liquor, as formerly prescribed.
4. Ground in upon the buff spots, the discharge No. 2, presently to be describe
5. Wash away the paste in chalky water.
6. Wince through a boiling alkaline ley, to raise the buff iron color.

IV. *The Discharge style ; first*, of simple discharges.

1. *Discharge for block printing.*

Take 1 gallon of lemon or lime-juice, of spec. grav. 1·09, in which dissolve
1 pound of tartaric acid,
1 pound of oxalic acid, and thicken the solution with
4 pounds of pipe or china clay, and 2 pounds of pulverized gum; as soon a
gum is dissolved, the mixture must be put through a searce.
2. Another discharge is made of half the above acid strength.
3. A third with one half of the solid acids of the second.
4. Take 1 gallon of water, in which dissolve with heat
1 pound of cream of tartar, adding, to facilitate the solution,
1 pound of warm sulphuric acid of spec. grav. 1·7674; after 24 hours mix
4 lbs. of pipe or China clay, and three lbs. of gum, with the decanted clear
In some cases British gum is used alone, as a thickener.
5. Discharge for the cylinder machine.

Take 1 gallon of lime-juice, of spec. grav. 1·085; dissolve in it
3 pounds of tartaric acid, and one pound of oxalic acid; thicken with
6 pounds of gum senegal, or 5 pounds of British gum.
6, 7. A stronger and weaker discharge is made of the same materials; and on
without the tartaric acid.

Second ; combination of discharges with mordants.

1. *Black, red, lilach, and white figures upon an olive ground.*

The olive being given in a madder bath, and the ground well whitened (see
the cloth is padded in a weak buff mordant; and upon the parts that are to rem
the weakest simple discharge No. 3 is printed-on by the cylinder; (in some wo
charge paste is applied and made dry before padding through the iron liquor;
are cleared of the paste in a tepid chalky water, then dyed in a quercitron ba
ing a little glue, and cleared in a bran bath.

Discharge mordants upon mordants may be regarded as a beautiful modific
preceding style. *Example.*

A violet ground or impression, with red and white.

1. Pad with an acetate of iron of 1·004; or print-on with the cylinder, i
1·027 thickened with British gum.
2. Print-on a red mordant, strongly acidulated with lime-juice of 1·226.
3. Ground in the discharge No. 2; dry. ·
4. Clear off the paste in chalky water.
5. Dung, madder, and brighten.
6. Ground-in the topical colors at pleasure.

V. China blues.

Take 16 pounds of coarsely ground indigo, and
4 pounds of sulphuret of arsenic; dissolve 22 pounds of sulphs
gallons of water; introduce these three matters into the indigo mill, and

three days. If it be wished to have a thickened blue, this mixture must have pounded gum added to it; but if not, 5 gallons of water are added. This color may be called blue No. 1.

The following table exhibits the different gradations of China blue:—

Course.	Quantity by measure of No. 1.	Quantity by measure of water or mucilage.
No. 1	1	0
2	11	1
3	10	2
4	8	4
5	6	6
6	4	8
7	2	10
8	2	12
9	2	14
10	2	16
11	2	18
12	2	20

I shall now give examples of working this style by the block and cylinder:—
Impression of a single blue with small dots.
For the block, blue No. 5, thickened with starch.
For the cylinder, No. 4, thickened with gum.
Impression of two different blues with the block.
First blue, No. 4, with starch.
Second blue, No. 9, with gum.
Impression of three blues with the block.
First blue, No. 5, with starch.
Second blue, No. 7, with starch.
Third blue, No. 10, with gum.
After printing-on the blues, the pieces are hung up for two days, in a dry and airy place, but not too dry; then they are dipped as follows:—Three vats are mounted, which may be distinguished by the numbers 1, 2, 3.
No. 1. 300 pounds of lime to 1,800 gallons of water.
No. 2. Solution of sulphate of iron of spec. grav. 1·048.
3. Solution of caustic soda of spec. grav. 1·055; made from soda crystals, quicklime, and water, as usual.
The pieces being suspended on the frames, are to be dipped in the first vat, and left in it ten minutes; then withdrawn, drained for five minutes; next plunged into the second vat for ten minutes, and drained also for five, &c. These operations will be most intelligible when put into the form of a table:—

Dip in the 1st vat.	During 10 minutes.	Drain during 5 minutes.
2	—	—
1	—	—
2	—	—
3	—	—
2	—	—
1	—	—
2	—	—
1	—	—
2	—	—
3	—	—

In the dipping of China blues, care should be taken to swing the frames during the operation; and when the last dip is given, the piece is to be plunged upon its frame into a fourth vat, containing dilute sulphuric acid of spec. grav. 1·027. This immersion is for the purpose of removing the oxyde of iron, deposited upon the calico in the alternate passages through the sulphate of iron and lime vats. They are then rinsed an hour in running water, and finally brightened in the above dilute sulphuric acid, slightly tepid. Sometimes they are subjected to a soap bath, at the temperature of 120°. By the addition of nitrate of lead to the indigo vat, the blue becomes more lively. Some use the roller dyeing apparatus for running the pieces through the respective baths instead of the square frames. (See WINCING.) But the frame-dip gives the most evenly dyes, and preserves the vats in good condition for a much longer time.

The various phenomena which occur in the dipping of China blues are not difficult of explanation with the lights of modern chemistry. We have, on the one hand, indigo and sulphate of iron alternately applied to the cloth; by dipping it into the lime, the blue is deoxydized, because a film of the sulphate of iron is decomposed, and protoxyde of iron comes forth to seize the oxygen of the indigo, to make it yellow-green, and soluble, at the same time, in lime-water. Then, it penetrates into the heart of the fibres, and, on exposure to air, absorbs oxygen, so as to become insoluble and fixed within their pores. On dipping the calico into the second vat of sulphate of iron, a layer of oxyde is formed upon its whole surface, which oxyde exercises an action only upon those parts that are covered with indigo, and deoxydizes a portion of it; thus rendering a second dose soluble by the intervention of the second dip in the lime-bath. Hence we see that while these alternate transitions go on, the same series of deoxydizement, solution, and re-oxydizement recurs; causing a progressively increasing fixation of indigo within the fibres of the cotton. A deposite of sulphate of lime and oxyde of iron necessarily falls upon the cloth, for which reason the frame should be shaken in the lime-water vat, to detach the sulphate; but, on the contrary, it should be held motionless in the copperas bath, to favor the deposition of as much protoxyde upon it as possible. These circumstances serve to account for the various accidents which sometimes befall the China blue process. Thus the blues sometimes scale off, which may proceed from one of two causes:—1. If the goods are too dry before being dipped, the color swells, and comes off in the vats, carrying along with it more or less of indigo. 2. If the quantity of sulphate of lime formed upon the cloth be considerable, the crust will fall off, and take with it more or less of the blue; whence arise inequalities in the impression. The influence of temperature is important; when it falls too low, the colors take a gray cast. In this case it should be raised with steam.

VI. The decoloring or *enlevage* style; not by the removal of the mordant, but the destruction of the dye. The acid, which is here mixed with the discharge paste, is intended to combine with the base of the chloride, and set the chlorine free to act upon the color. Among the topical colors for this style are the following:—

1. *Black.*—Take one gallon of iron liquor of spec. grav. 1·086.
    One pound of starch; boil together, and while the paste is hot, dissolve in it
    One pound of tartaric acid in powder; and when cold, add
    Two pounds of Prussian blue, prepared with muriatic acid, see p. 232.
    Two ounces of lamp black, with four ounces of oil.

2. *White discharge.*—Take one gallon of water, in which dissolve
    One pound and a half of oxalic acid,
    Three pounds of tartaric acid; add
    One gallon of lime-juice of spec. grav. 1·22; and thicken with
    Twelve pounds of pipe clay, and six pounds of gum.

3. *Chrome-green discharge.*—
    Take one gallon of water, thicken with 18 ounces of starch;
      boil and dissolve in the hot paste;
    Two pounds and a half of powdered nitrate of lead,
    One pound and a half of tartaric acid,
    Two pounds of Prussian blue, as above.

4. *Blue discharge.*—Take one gallon of water, thicken with
    18 ounces of gum; while the boiled paste is hot, dissolve in it
    Two pounds of tartaric acid, and mix one pound of Prussian blue.

5. *Chrome-yellow discharge.*—This is the same as the chrome-green given above, but without the Prussian blue.

6. *A white discharge on a blue ground* requires the above white discharge to be strengthened with 8 ounces of strong sulphuric acid, per gallon.

7. *White discharge for Turkey red* needs to be very strong.
Take one gallon of lime-juice of sp. grav. 1·086; dissolve in it
Five pounds of tartaric acid; thicken with
Eight pounds of pipe-clay, four pounds of gum; then dissolve in the mixture
Three pounds of muriate of tin in crystals; and add, finally,
Twenty-four ounces of sulphuric acid.

8. *Yellow discharge for Turkey red.*—
    Take one gallon of lime-juice of spec. grav. 1·086; in which dissolve
    Four pounds of tartaric acid,
    Four pounds of nitrate of lead; thicken the solution with
    Six pounds of pipe-clay, and three pounds of gum.

9. *For green discharge*, add to the preceding 24 ounces of Prussian blue, as above.
The decoloring or chlorine bath is usually formed of wood lined with lead, and has an area of about 5 feet square, with a depth of 6 feet. A square frame, mounted with a horizontal series of rollers at top and bottom, may be let down by cords,

pleasure, into the cistern. The pieces are introduced and guided in a serpentine path, round the upper and lower rollers alternately, by a cord.

This bath is filled with a solution of chloride of lime, of the spec. grav. 1·045, whose decoloring strength is 65° by Gay Lussac's indigo chlorometer. It ought to be made turbid by stirring before putting in the goods, which should occupy three minutes in their passage. The piece is drawn through by a pair of squeezer cylinders at the end of the trough, opposite to that at which the piece enters. With black, white, and blue impressions of all shades, the goods are floated in a stream of water for an hour; then rinsed and dried. When there is yellow or green, the pieces must be steeped in water, then merely washed by the wince, and passed through solution of bichromate of potash, containing from 3 to 5 ounces of the salt per piece. Here the pieces are winced during 15 or 20 minutes, rinsed, and next passed through dilute muriatic acid to clear the ground; then rinsed and dried.

Discharge by the intervention of the chromic acid.

After having dipped the pieces to the desired shade, they are padded in a solution of bichromate of potash; dried in the shade without heat; and then printed with the following mordant :—

> Take 1 gallon of water; dissolve in it
> 2 pounds of oxalic and 1 pound of tartaric acid; thicken with
> 6 pounds of pipe-clay, and 3 pounds of gum; lastly, add
> 8 ounces of muriatic acid.

After the impression, the pieces are winced in chalky water, at 120° F., then washed, and passed through a dilute sulphuric acid.

M. Daniel Kœchlin, of Mulhausen, the author of this very ingenious process, considers the action of the bichromate here as being analogous to that of the alkaline chlorides. At the moment that the block applies the preceding discharge to the bichromate dye, there is a sudden decoloration, and a production of a peculiar odor.

The pieces padded with the bichromate must be dried at a moderate temperature, and in the shade. Whenever watery solutions of chromate of potash and tartaric acid are mixed, an effervescence takes place, during which the mixture possesses the power of destroying vegetable colors. This property lasts no longer than the effervescence.

VII. *Steam colors.*—This style combines a degree of brilliancy with solidity of color, which can hardly be obtained in any other way except by the chints dyes. The steam apparatus employed for fixing colors upon goods, may be distributed under five heads:—1. the column; 2. the lantern; 3. the cask; 4. the steam-chest; and, 5. the chamber.

The column is what is most generally used in this country. It is a hollow cylinder of copper, from three to five inches in diameter, and about 44 inches long, perforated over its whole surface with holes of about one sixteenth of an inch, placed about a quarter of an inch asunder. A circular plate, about 9 inches diameter, is soldered to the lower end of the column, destined to prevent the coil of cloth from sliding down off the cylinder. The lower end of the column terminates in a pipe, mounted with a stop-cock for regulating the admission of steam from the main steam-boiler of the factory. In some cases, the pipe fixed to the lower surface of the disc is made tapering, and fits into a conical socket, in a strong iron or copper box, fixed to a solid pedestal; the steam pipe enters into one side of that box, and is provided, of course, with a stop-cock. The condensed water of the column falls down into that chest, and may be let off by a descending tube and a stop-cock. In other forms of the column, the conical junction pipe is at its top, and fits there into an inverted socket connected with a steam chest, while the bottom has a very small tubular outlet, so that the steam may be exposed to a certain pressure in the column, when it is incased with cloth.

The pieces, after being printed with the topical colors presently to be described, and dried, are lapped round this column, but not in immediate contact with it; for the copper cylinder is first enveloped in a few coils of blanket stuff; then with several coils of white calico; next with the several pieces of the printed goods, stitched endwise; and lastly, with an outward mantle of white calico. In the course of the lapping and unlapping of such a length of webs, the cylinder is laid in a horizontal frame, in which it is made to revolve. In the act of steaming, however, it is fixed upright, by one of the methods above described. The steaming lasts for 20 or 30 minutes, according to the nature of the dyes; those which contain much solution of tin admit of less steaming. Whenever the steam is shut off, the goods must be immediately uncoiled, to prevent the chance of any aqueous condensation. I was much surprised, at first, on finding the unrolled pieces to be free from damp, and requiring only to be exposed for a few minutes in the air, to appear perfectly dry. Were water condensed during the process, it would be apt to make the colors run.

Steam colors are all topical, though, for many of them, the pieces are previously

padded with mordants of various kinds. Some manufacturers run the goods before printing them through a weak solution of the perchloride of tin, with the view of brightening all the colors subsequently applied or raised upon them. I shall now illustrate steam calico-printing by some examples, kindly furnished me by a practical printer near Manchester, who conducts a great business with remarkable success.

Steam blue.—Prussiate of potash, tartaric acid, and a little sulphuric acid, are dissolved in water, and thickened with starch; then applied by the cylinder, dried at a moderate heat, and steamed for 25 minutes. They are rinsed and dried after the steaming. The tartaric acid, at a high temperature, decomposes here a portion of the ferrocyanic acid, and fixes the remaining ferrocyanate of iron (Prussian blue) in the fibre of the cloth. The ground may have been previously padded and dyed; the acids will remove the mordant from the points to which the above paste has been applied, and bring out a bright blue upon them.

Steam purple.—This topical color is made by digesting acetate of alumina upon ground logwood with heat; straining, thickening with gum senegal, and applying the paste by the cylinder machine.

Steam pink.—A decoction of Brazil-wood with a small quantity of the solution of muriate of tin, called, at Manchester, new tin crystals,[*] and a little nitrate of copper to assist in fixing the color; properly thickened, dried, and steamed for not more than 20 minutes, on account of the corrosive action of muriate of tin when the heat is too strong.

Cochineal pink.—Acetate of alumina is mixed with decoction of cochineal, a little tartaric acid and solution of tin; then thickened with starch, dried, and steamed.

Steam brown.—A mixed infusion of logwood, cochineal, and Persian berries, with cream of tartar, alum (or acetate of alumina), and a little tartaric acid, thickened, dried, and steamed.

Green, blue, chocolate, with white ground, by steam.—Prussiate of potash and tartaric acid, thickened, for the blue; the same mixture with berry-liquor and acetate of alumina thickened, for the green; extract of logwood with acetate of alumina and cream of tartar, thickened, for the chocolate. These three topical colors are applied at once by the three-color cylinder machine; dried and steamed. Though greens are fixed by the steam, their color is much improved by passing the cloth through solution of bichromate of potash.

In France, solution of tin is much used for steam colors.

VIII. *Spirit or fancy colors.*—These all owe their vivacity, as well as the moderate degree of permanency they possess, to their tin mordant. After printing-on the topical color, the goods must be dried at a gentle heat, and passed merely through the rinsing machine. Purple, brown, or chocolate, red, green, yellow, blue, and white discharge; any five of these are printed on at once by the five-color cylinder machine. See RINSING MACHINE.

Chocolate is given by extract of Brazil-wood, extract of logwood, nitro-muriate of tin, with a little nitrate of copper: all mixed, thickened, and merely printed-on.

Red, by extract of Brazil-wood and tin, with a little nitrate of copper.

Green, by prussiate of potash, with muriate of tin and acetate of lead, dissolved, thickened, and printed-on.

The goods after rinsing must be passed through solution of bichromate of potash, to convert the Prussian blue color into green, by the formation of chrome yellow upon it.

Blue.—Prussian blue ground up with solution (nitromuriate) of tin; thickened, &c.

Yellow.—Nitrate of lead dissolved in solution of tartaric acid, thickened, tenderly dried, passed through the bichromate vat or padding machine, washed and dried. This yellow is pretty fast; though topical, it can hardly, therefore, be called a fancy color.

When *purple* is to be inserted instead of the above blue, extract of logwood with tin is used in the place of the Prussian blue. Tartaric acid is a useful addition to tin in brightening fancy colors.

Chocolate.—A good topical chocolate is made by digesting logwood with liquid acetate of alumina, adding a little cream of tartar to the infusion; thickening, applying by the cylinder, drying, washing, then passing through solution of bichromate of potash, which serves to darken and fix the color.

I shall conclude my account of the printing of cotton goods with some miscellaneous formulæ, which were given me by skilful calico-printers in Lancashire.

Prussian blue is prepared for topical printing by grinding it in a handmill, like that for grinding pepper or coffee, and triturating the powder with solution of muriate of tin.

Green.—The deoxydized indigo vat liquor is mixed with a little pearlash, and thickened with gum. This is applied by the cylinder or block to goods previously

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[*] This preparation is made by adding 3 lbs. of sal ammoniac to 1 gallon of solution of tin (*see* SCARLET DYE, and TIN), evaporating, and crystallizing. The sal ammoniac seems to counteract the separation of the tin by peroxydizement.

padded with nitrate of lead; the goods, after being dried, are passed through milky lime-water, rinsed, and then winced or padded through the bichromate of potash bath.

Another green.—Nitrate of lead, prussiate of potash, and tartaric acid, dissolved, and mixed with a little sulphate, nitrate, and muriate of iron; this mixture is either thickened for cylinder printing, or used in its liquid state in the padding trough. The goods subjected to one of these two processes are dried, padded in weak solution of carbonate of potash, which serves to precipitate the oxyde of lead from the nitrate; they are finally padded with bichromate of potash, which induces a yellow upon the blue, constituting a green color of any desired tint, according to the proportion of the materials.

Chocolate and black, with white discharge; a fast color.—The cloth is padded with acetate of alumina, and dried in the hot-flue; it is then passed through a two-color machine, the one cylinder of which prints-on lime-juice discharge, thickened with gum senegal; the other a black topical dye (made with logwood extract and iron liquor). The cloths are now hung up to be aired during a week, after which they are dunged, and dyed up with madder, fustic, and quercitron bark, heated with steam in the bath.

Blue, white, and olive or chocolate.—1. Pad with the aluminous mordant; 2. Apply thickened lemon-juice for discharge by the cylinder; 3. Dung the goods after they are thoroughly dried; 4. Pass them through the bath of madder, fustic, and quercitron, which dye a brown ground, and leave the discharge points white; then print-on a reserve paste of China clay and gum with sulphate of copper; dry, dip in the blue vat, which will communicate an olive tint to the brown ground; or a chocolate, if madder alone had been used.

When a black ground is desired, with white figures, the acid discharge paste should be printed-on by the cylinder, and dried before the piece is padded in the iron liquor. By following this plan the whites are much purer than when the iron is first applied.

Green, black, white.—The black is first printed-on by a mixture of iron liquor, and infusion (not decoction) of logwood; then resist or reserve paste is applied by the block, and dried; after which the goods are blued in the indigo vat, rinsed, dried, passed through solution of acetate of lead; next, through milky lime-water; lastly, through a very strong solution of bichromate of potash.

Turkey red, black, yellow.—Upon Turkey red cloth, print with a strong solution of tartaric acid, mixed with solution of nitrate of lead, thickened with gum; dry. The cloth is now passed through the chloride of lime bath, washed, and chromed. Lastly, the black is printed-on by the block as above, with iron liquor and logwood.

Black ground dotted white, with red or pink and black figures.—1. Print-on the lime-juice discharge-paste by the cylinder; dry; 2. Then pad with iron liquor, containing a little acetate of alumina, and hang up the goods for a few days to fix the iron; 3. Dye in a logwood bath to which a little madder has been added; clear with bran. The red or pink is now put in by the block, with a mixture of extract of Brazil-wood, nitromuriate of tin, and nitrate of copper, as prescribed in a preceding formula.

Orange or brown; black; white; pink.—The black is topical, as above; it is printed-on, as also the lemon-juice discharge and red mordant, with muriate of tin (both thickened), by the three-color machine. Then, after drying the cloth, a single-cylinder machine is made to apply in diagonal lines to it a mixture of acetate of iron and alumina. The cloth, being dried and dunged, is next dyed in a bath of quercitron, madder, and fustic.

Here the orange is the result of the mordant of tin and alumina; the brown, of the alumina and iron; white, of the citric acid discharge. The tin mordant, wherever it has been applied, resists the weaker mordant impressed in the diagonal lines. The pink is blocked-on at the end.

Orange brown, or aventurine; black and white.—The topical black (as above) and discharge lemon-juice, are printed-on by the two-color machine; then the cloth is subjected to the diagonal line cylinder, supplied with the alumino-iron mordant. The cloth is dried, dunged, and dyed in a bath of bark, madder, and fustic.

The manganese or *solitaire* ground admits of a great variety of figures being easily brought upon it, because almost every acidulous mordant will dissolve the oxyde of manganese from the spot to which it is applied, and insert its own base in its place; and of course, by dyeing such mordanted goods in various baths, any variety of colored designs may be produced. Thus, if the paste of nitrate of lead and tartaric acid solution be applied, and the goods after drying be passed first through lime-water, and then through a chrome bath, bright yellow spots will be made to appear upon the bronze ground.

Manganese bronze, buff and green; all metallic colors.—Pad-on the manganese solution, and dry; apply the aceto-sulphate of iron, of spec. grav. 1·02, and Scheele's green (both properly thickened), by the two-color machine. The goods are next to be dried, and padded through a cold caustic ley of spec. grav. 1·086. They are then

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rinsed, and passed through a weak solution of chloride of lime, to raise the bronze, again rinsed, and passed through a solution of arsenious acid to raise the green.

Scheele's green for the calico-printer is made as follows :—

Take 1 gallon of water, in which dissolve with heat,

5 pounds of sulphate of copper, and 1 pound of verdigris. When the two salts are dissolved, remove the kettle from the fire, and put into it 1 quart of solution of nitrate of copper, and 5 pounds of acetate of lead. Stir the mixture to facilitate the decomposition, and allow the pigment to subside.

It must be thickened with 2½ lbs. of gum per gallon, for pencilling; or 12 oz. of starch for the block. The goods printed with this paste are to be winced through a caustic ley, till a fine sky-blue be produced; then washed well and rinsed. They are now to be passed through water, containing from half an ounce to an ounce of white arsenic per piece; 4 turns are sufficient; if it be too long immersed it will take a yellow tint.

Catechu has been considerably employed by calico-printers of late years, as it affords a fine permanent substantive brown, of the shade called *carmelite* by the French. The following formula will exemplify its mode of application :—

Take 1 gallon of water;

1 pound of catechu in fine powder; reduce by boiling to half a gallon, pass the decoction through a fine sieve, and dissolve in it 4 ounces of verdigris; allow it then to cool, and thicken the solution with 5 ounces of starch; while the paste is hot, dissolve in it 5 ounces of pulverized muriate of ammonia.

Print-on this paste, dry, and wash. It is a fast color.

I shall subjoin the prescriptions for two fancy cochineal printing colors.

Amaranth by cochineal.—Pad the pieces in the aluminous mordant of spec. grav. 1·027, page 230.

Dry in the hot flue; and after hanging up the goods during 3 days, wince well through chalky water, and then dye, as follows :—

For each piece of 28 or 30 yards, 8 ounces of cochineal are to be made into a decoction of 2 gallons in bulk, which is to be poured into a kettle with a decoction of 3 ounces of galls, and with two ounces of bran. The pieces are to be entered and winced as in the madder bath, during two hours and a half; then washed in the dash wheel. On mixing with the amaranth bath a certain quantity of logwood, very beautiful lilachs and violets may be obtained.

Mixture of quercitron and cochineal.—Pad in the aluminous mordant, and dye with 2 lbs. of quercitron, and 4 ounces of cochineal, when a capuchin color will be obtained. If we pad with the following mordant, viz., 1 gallon of acetate of alumina of 1·056 spec. grav., and 1 of iron liquor of 1·02 spec. grav., and dye with 1 pound of quercitron, and 1 ounce of cochineal, we shall obtain a shade like boot-tops, of extreme vivacity.

Two ounces of cochineal will print a long piece of calico with rich pink figures, having acetate of alumina for a mordant. As the ground is hardly tinged by the dye, it neither needs nor admits of much clearing.

I have already mentioned that goods are sometimes padded with solution of perchloride of tin before printing-on them the steam colors, whereby they acquire both permanence and vivacity. I have also stated that the salts of tin at a high temperature are apt to corrode the fibre of the stuff, and therefore must be used with discretion. This danger is greatly lessened by adding to the perchloride of tin a sufficient quantity of caustic potash ley to form a stannate of potash. The goods are padded through this substance diluted with water, dried with a moderate heat, and then immersed in very dilute sulphuric acid, which saturates the potash, and precipitates the tin oxyde within the pores of the cloth. Calico thus prepared affords brilliant and permanent colors by the steam process, above described.

Printing of silks or woollen stuffs, such as merinoes and mousseline de laine, as also of printed stuffs of silk and wool, such as chalys.—All these prints are applied, not by the cylinder but the block, and are fixed by the application of steam in one of four ways; 1. the *lantern*; 2. By the *cask*; 3. By the *chest*; or, 4. By the *chamber*.

1. *By the lantern.*—In this mode of exposure to steam, the goods are stretched on a frame; and therefore the apparatus may be described under two heads; the lantern and the frame. The former is made of copper, in the shape of a box A B C D E, *fig.* 238, or below, and with a sloping roof above, to facilitate the trickling down of the water condensed upon the walls. The sides B C D E are 4½ feet high, 6 feet long, and 4 feet wide. The distance of the point A from the line E B is 2 feet. At F is a brass socket, which may be stopped with a cork; and there is a similar one at the other side. This kind of penthouse may be raised by means of a pulley with cords fixed to the four angles of the roof E B; and it rests upon the table G H, a little larger than the area of the box, which stands upon the four feet I K. Round the borders of the table there is a triangular groove a b, for receiving the lower edges of the box, and it is stuffed steam-tight with lists of cloth. Through the centre of the table, the two-inch steam pipe M

passes; it is surmounted with a hemispherical rose pierced with numerous holes for the equal distribution of the steam. Right above it, a disc N is placed upon four feet. The tube L communicates with a box P, which has a syphon Q to let off the condensed water. At the upper part of this box the tube L terminates which brings the steam. The little table G H slopes towards the part G, where the syphon R is placed for drawing off the water.
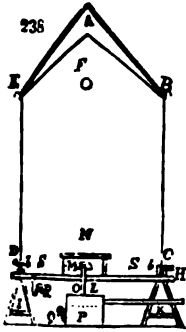
The *frame* has such dimensions, that it may stand in the four corners of the table at s s, as pointed out by the dotted lines. The second part embraces an open square frame, which is formed by spars of wood 2 inches square, mortised together; and is 3 feet 8 inches wide, 5 feet 8 inches long, and 4 feet 3 inches high; it is strengthened with cross bars. Upon the two sides of its breadth, two rows of round brass hooks are placed, about half an inch apart; they are soldered to a copper plate fixed to uprights by means of screws.

Before hanging up the goods, a piece of cloth 3 feet 8 inches long, and 4 feet wide, is placed upon the row of hooks; and 3 feet of it are left hanging out.

One foot within, the hooks pass through the cloth. A similar one is fitted to the other side. This cloth is intended to cover the goods hung upon the hooks; and it is kept straight by resting upon strings. The pieces are attached zig-zag from one hook to another. When the frame is filled, the bag is put within the cloths; it has the same rectangular shape as the frame. The pieces are in this way all incased in the cloth; a bit of it being also put beneath to prevent moisture affecting that part.

When shawls are framed, they are attached with pins; and if they be too large, they are doubled back to back, with the fringes at top.

These arrangements being made, the frame is set upon the table, the penthouse is placed over it, and the steam is admitted during from 35 to 45 minutes, according to circumstances. The orifice F is opened at first to let the air escape, and when it begins to discharge steam it is stopped. The frame is taken out at the proper time, the bag is removed, the cloths are lifted off, and the goods are spread out for airing. Three frames and six bags are required for a constant succession of work. The above apparatus is particularly suitable for silks.

2. *The drum.*—This is the most simple mode of steaming. The apparatus is a drum of white wood, 2 inches thick, *fig.* 239; the bottom is pierced with a hole which admits the steam-pipe F, terminating in a perforated rose. Four inches from the bottom there is a canvass partition E, intended to stop any drops of water projected from the tube F, and also to separate the condensed water from the body of the apparatus. The drum is covered in by a wooden head H, under which the goods are placed. It is made fast either by bolts, or by hooks, G G, thus ∽, to which weighted cords are hung. The frame 1, *fig.* 240, rests upon a hoop, a a, a few inches from the edge. The goods are hung upon the frame in the ordinary way, and then wrapped round with flannel. The frame is studded with pin points, like that of the indigo vat, fixed about 5 inches asunder. From 20 to 30 minutes suffice for one steaming operation. The upper part of the frame must be covered also with flannels to prevent the deposition of moisture upon it. At the bottom of the drum there is a stopcock to let off the condensed water. According to the size of the figure, which is 3 feet 2 inches, 50 yards may be hung up single; but they may be doubled on occasion.
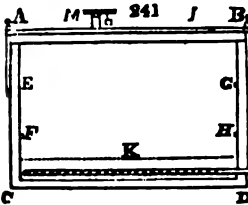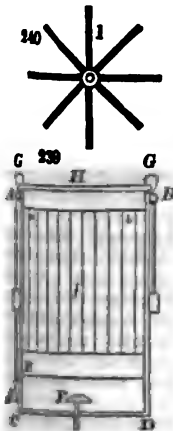
3. *The box.*—This steaming apparatus is convenient from the large quantity of goods admissible at a time: it answers best for woollen stuffs. From 12 to 16 pieces, of 36 yards each, may be operated upon at once; and from 240 to 260 shawls. It is formed of a deal box, A B C D, *fig.* 241, 4 feet wide, 6 feet long, and 3 high; the wood being 4 inches thick. It is closed by a cover of the same substance, I, which is made steam-tight at the edges by a list of felt. The lid is fastened down by 5 cross bars of iron, a a a a a, which are secured by screws, c c c c c, *fig.* 242. The ends of these cross bars are let into the notches, b b b b b, on the edge of the box. The safety valve M, *fig.* 241, is placed upon the lid. For taking off the lid, there are rings at the four

corners, *d d d d*, bearing cords, F F F F. These join at the centre into one, which passes over a pulley. Eight inches from the bottom of the box there is a horizontal canvass par-

tition, beneath which the steam is discharged from the pipe L, *fig.* 243. There are two ledges, E F G H, at the sides for receiving the bobbins. The tube L runs round the box, as shown by the letters *d a e b* : the end *d* is shut; but the side and top are perforated with many holes in the direction towards the centre of the box. *Fig.* 244 shows the arrangement of the lower set of bobbins : that of the upper set is shown by the dotted lines : it is seen to be in an alternate position, one lying between two others. They are formed of pieces of deal 4 inches broad, 1 inch thick, and of a length equal to the width of the box. They are first wrapped round with 5 or 6 turns of doubled flannel or calico : the piece of goods is laid over it upon a table, and then wrapped round. At the end of the piece, several folds of the covering must be put, as also a roll of flannel. The two ends must be slightly tied with packthread. When these flat bobbins are arranged in a box, the steam is let on them, and continued about 45 minutes; it is then shut off, the lid is removed, and the pieces are unrolled.
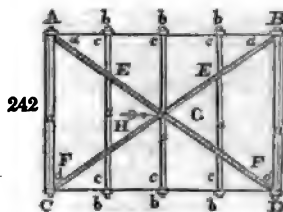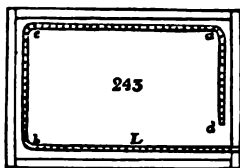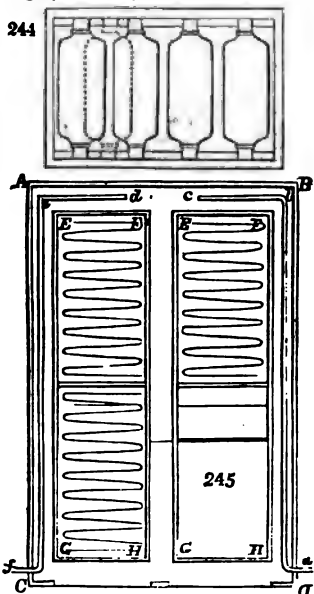
4. *The chamber.*—The interior height of the chamber, A B C D, *fig.* 245, is nine feet, the length 12 feet, and the breadth 9 feet. The steam is introduced into it by two pipes, *a b c, d e f.* Their two ends, *d c*, are shut; but their sides are all along perforated with small holes. The frames E F G H, E F G H, are moveable, and run upon rollers : they are taken out by front doors, which are made of strong planks, shut by sliding in slots, and are secured by strong iron bars and pressure screws. The cross rods, E F G H, are provided with hooks for hanging up the pieces. There is a safety-valve in the top of this large chamber. The dimensions of the frame are ten feet long, 3 feet wide, and 7 high. Three feet and a half from the upper part of the frame, a row of hooks is fixed for hanging on a double row of pieces, as shown in the figure. Over the frame, woollen blankets are laid to protect it from drops of water that might fall from the roof of the chamber. When the hooks are two thirds of an inch apart, 24 pieces, of 28 yards each, may be suspended at once. The period of steaming is from 45 to 60 minutes.

Muslins and silks do not require so high a temperature as woollen goods. When the stuffs are padded with color, like merinoes and chalys, they must not be folded together, for fear of stains, which are sometimes occasioned by the column in steam calico-printing, where the end which receives the first impression of the steam is seldom of the same shade as the rest of the roll of goods. The duration of the steaming depends upon the quantity of acid in the mordant, and of saline solution in the topical color; the more of which are present the shorter should be the steaming period. A dry vapor is requisite in all cases; for when it becomes moist, from a feeble supply or external condensation, the goods become streaky or stained by the spreading of the colors.

1. *Black figures* are given by decoction of logwood thickened with starch, to which a little oxalic acid is added while hot, and, after it is cold, neutralized solution of nitrate of iron.

2. *Dark blue for a ground.*—Decoction of logwood, and archil thickened with starch; to which, while the paste is hot, a little soluble Prussian blue is added; and, when it is cold, neutralized nitrate of iron; see *supra.*

3. *Deep poppy or ponceau color.*—Cochineal boiled in starch water, with oxalic acid (or tartaric), and perchloride of tin.

4. *Rose.*—Cochineal infusion; oxalic acid; perchloride of tin; thickened with gum.

5. *Dark amaranth.*—Decoctions of archil and cochineal, thickened with starch: to the paste, alum and perchloride of tin are added.

6. *Capuchin color.*—Quercitron and cochineal thickened with starch; to the paste add oxalic acid and perchloride of tin.

7. *Annotto orange.*—Dissolve the annotto in soda ley, of spec. grav. 1·07, at a boiling heat; add aluminate of soda, and thicken with gum.

8. *Golden yellow.*—Decoction of Persian berries thickened with starch; to which some alum and muriate of tin are added, with a little perchloride of tin and oxalic acid.

9. *Lemon yellow.*—Persian berries; starch; alum.

10. An ammoniacal solution of cochineal is used for making many violet and mallow colors. It is prepared by infusing cochineal in water of ammonia for 24 hours; then diluting with water, heating to ebullition, and straining.

11. *Fine violet* is given by ammoniacal cochineal, with alum and oxalic acid; to which a little aceto-sulphate of indigo is added, and gum for thickening. The following blue may be used instead of the solution of indigo. The *mallow* tint is given by adding a little perchloride of tin to the above formula, and leaving out the blue.

12. *Dark blue.*—Soluble Prussian blue; tartaric acid; alum; thicken with gum.

13. *Emerald green.*—One quart of decoction, equivalent to 1 pound of Persian berries; 1 quart of infusion of quercitron, of spec. grav. 1·027; in which dissolve 12 ounces of alum in powder; and add 6 ounces of the following blue bath for greens; thicken with 20 ounces of gum.

14. *Blue bath for greens.* Half a gallon of water at 140° F., one pound of soluble Prussian blue, 3 ounces of tartaric acid, and 2 ounces of alum.

I. *Printing of Silks.*—1. *Of the madder style.* This is one of the most difficult to execute, requiring both much skill and experience. The first step is the removal of the gum. A copper being nearly filled with water, the pieces, tied up in a linen bag, are put into it, with a quarter of a pound of soap for every pound of silk, and are boiled for 3 hours. If the silk be Indian, half an ounce of soda crystals must be added. When the goods are taken out, they are rinsed in the river, then passed through water at 140° F., holding 8 ounces of crystallized soda in solution, as a scourer. They are next rinsed in cold water, and steeped in water very faintly acidulated with sulphuric acid, during 4 hours, then rinsed, and dried.

Preparation of Mordants.—1 gallon of boiling water; 2 pounds of alum; dissolve: 1 pound of acetate of lead; 4 ounces of sal-ammoniac; 1 of chalk; mix well together; after decomposition and subsidence, draw off clear.

1. *Red.*—1 gallon of the above mordant, thickened with 14 ounces of starch, and tinged with decoction of Brazil-wood. If dark red be wanted, dissolve, in a gallon of the above red, 4 ounces of sulphate of copper.

2. *Black.*—1 gallon of iron liquor, of 1·056 spec. grav.; thicken with 14 ounces of starch; and dissolve in the hot paste 2 ounces of sulphate of copper.

3. *Violet.*—Take 1 gallon of iron liquor of 1·04 spec. grav.;
        2 ounces of cream of tartar; 2 ounces of nitre; 2 ounces of copperas;
        1 ounce of alum: dissolve, and mix the solution with
        1 gallon of gum water, containing 6 lbs. of gum.

4. *Puce.*—Half a gallon of red mordant; half a gallon of iron liquor of 1·07;
        7 ounces of starch for thickening; color with logwood.

Manipulation of the above colors.—Print-on the black, then the puce, next the violet, and lastly the red. Dry in the hot flue, and 48 hours after the impression, wash away the paste. The copper employed for dyeing is of a square form: a boil is given with bran, at the rate of 4 lbs. per piece of the *foulards*: cold water is added to lower the temperature to 130° F. The pieces must be entered with the printed surface undermost, and winced for half an hour, taking care to keep them expanded and well covered with the liquor: they are then taken out and rinsed. When grounds are to be made on the foulards, 2 ounces of sumach must be added per piece.

Maddering.—Suppose 48 pieces are to be grounded with madder. 12 pounds of madder must be put into the copper, 1 pound of sumach, and 6 pounds of bran; the bath must be tepid when the pieces are entered: it must be heated to 104° F. in 20 minutes, and to the boiling point in an hour and a half. The goods must be briskly winced all the time, and finally turned out into cold water.

When they come out of the madder bath they are much loaded with color. They are cleared by a boil of half an hour in bran, then turned out into cold water, and rinsed. A copper must be now mounted with 3 pounds of soap, 1 ounce of solution of tin, and 2 pailsful of bran, in which the goods are to be boiled for half an hour, then rinsed, and passed through a very dilute sulphuric acid bath. Then rinse, and dry. By following this process, a light salmon ground is obtained.

II. *Steam colors upon silk.*—The same plan of operations may be adopted here as described for calico-printing; the main difference being in the method of mordanting the stuffs. After boiling in soap water, in the proportion of 4 ounces per pound of silk, the goods are washed in cold water, and then in hot water at 140°; they are next rinsed, passed through weak sulphuric acid, rinsed, squeezed between rollers, and afterwards steeped in a bath containing 8 ounces of alum per gallon, where they remain for four hours, with occasionally wincing. They are now rinsed and dried. The subsequent treatment resembles that of steam-color printed cottons.

Black.—Take a gallon of decoction, made with 4 lbs. of logwood, with which
        14 ounces of starch are to be combined : mix in
        2 ounces of powdered nut-galls : boil, and pour the color into a pipkin con-
            taining
        2 ounces of tartaric acid ; 2 ounces of oxalic, both in powder, and
        2 ounces of olive oil. Stir the color till it is cold, and add
        8 ounces of nitrate of iron, and 4 ounces of nitrate of copper.

The red, violet, lilach, yellow colors, &c. are the same as for steam colors upon cotton. Topical colors are also applied without mordanting the silk beforehand. In this case a little muriate of tin is introduced. Thus, for

Yellow.—Take 1 gallon of a decoction, made with 4 lbs. of Persian berries : dissolve
        in it 8 ounces of salt of tin (muriate), and 4 ounces of the nitro-muriatic
        solution of tin. Thicken with 2 pounds of gum.

Printing of foulard pieces. The tables which serve for the impression of silk goods are so constructed as to receive them in their full breadth. Towards the part between the color or sieve tub and the table, the roller is mounted upon which the piece is wound.

This roller, A B, *fig.* 216, has a groove, c, cut out parallel to its axis. Into this a bar is pressed, which fixes the end of the piece. The head, B, of the roller is pierced with several holes, in which an iron pin passes for stopping its rotation at any point, as is shown at B. At the other end of the table there is placed a comb, *fig.* 247, which is supported by pivots A B at its ends. The teeth of the comb are on a level with the cloth.

The piece is arranged for printing as follows :—It is unwound, and its end is brought upon the teeth of the comb, and made to pass into them by slight taps with a brush. It is now stretched, by turning round the roller, and fixing it by the pin-handle. After tracing the outline, the printing blocks are applied. Care should be taken, in the course of printing, always to fix the teeth of the comb in the middle line between two handkerchiefs. The operation of grounding-in is much facilitated by this plan of extension.

The pieces are washed in running water, and must be rapidly dried. The subsequent dressing is given by gum tragacanth : they are dried upon a stretching frame, and then folded up for the market.

III. *Mandarining of silk stuffs and chalys.*—This style of printing depends upon the property which nitric acid possesses of giving to silk and woollen stuffs a yellow color.

The first step is the scouring with a soap boil, as already described.

The designs are printed-on as also above described.

The swimming or color tub is usually double, and serves for two tables; instead of being placed, therefore, at the end of the table, it is put between two, and, conse-

quently, behind the printer. It is formed of a copper chest, *fig.* 248, A B C D, in which steam may circulate, introduced by the pipe I; the excess being allowed to escape by the tube J, as also the water of condensation. The frame is placed in the hollow box K K. Between two such frames there is a plate of copper, L, which closes the box; it serves for laying the plates in order to keep them hot. At F and H are prolongations of the box, in which are set the vessels F G for holding the reserve paste.

Preparation of the reserve or resist paste.—Melt in a kettle 2½ lbs. of rosin; 1 lb. of suet; mix well, and put it into the basins F' G'. By means of steam the reserve is kept melted, as well as the false color upon which the sieve floats. The piece of silk being laid upon the table, and the reserve spread upon the frame, the printer heats his block, which should be mounted with lead, if the pattern will permit, upon the little table L. He takes up the color from the frame, and transfers it instantly to the piece. He must strike the block lightly, and then lift it, lest, by its cooling, it might stick to the silk. When the table pattern is completed, he dusts it over with sand, and proceeds to another portion of the silk. The piece must not be
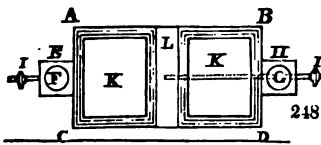
taken out of the stretch till it is quite dry, which requires usually 6 hours. Let us consider first the most common case, that of a white upon an orange ground. We shall afterwards describe the other styles, which may be obtained by this process. The piece, being printed and dry, must next be subjected to the *mandarining* operation.
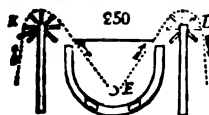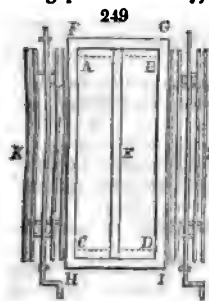
The apparatus here employed consists of a sandstone trough A B C D, *fig.* 249. Upon the two sides, A C, B D, of this trough are fixed two wooden planks, pierced with a hole an inch from the bottom to receive the roller E, under which the piece passes. In this trough the acid mixture is put. That trough is put into a wooden or copper trough, F G H I. Into the latter, water is put, which is heated by means of steam, or a convenient furnace. Before and behind are placed two winces, or reels, K L; one serves to guide the piece in entering into the trough, and the other in its leaving it. The piece falls immediately into a stream of cold water, or, failing that, into a large back, containing a mixture of chalk and water. The two winces are moved by handles: the velocity is proportioned to the action of the acid. The wince L ought to be higher than K, to allow the acid to drain off. *Fig.* 250 shows a section of the apparatus.

The temperature of the acid mixture ought to be maintained between 95° and 100° F.; for if it be raised higher, the resist would run the risk of melting, and the impression would become irregular and blotty.

The proportions of the acid mixture are the following :—

1 gallon of water; and 1 gallon of nitric acid, of spec. grav. 1·288, which may be increased with the strength of the silk. It should be a little weaker for chalys. For the strong greens it may be 2 measures of acid of 1·288 to 1 measure of water. The duration of the passage through the acid should be 1 minute at most.

Mixture of orange color, and clearing away of the resist.—The goods, on coming out of the mandarining apparatus, are rinsed in running water; then boiled in soap water, quickened with a little soda, at the rate of 2 lbs. of the former and 4 oz. of the latter for a piece of 30 yards. They must be worked by the wince for half an hour. They are now rinsed in cold water, then passed through hot, again rinsed, and dried. I shall give some examples of the mode of manufacture, which is undoubtedly one of the most curious applications of chemical ingenuity.

1. *Orange ground with white figures.*

(1.) Print-on the fat reserve; (2.) mandarine; (3.) brighten the orange, and clear.

2. *Orange ground with blue figures.*

(1.) Dip in the indigo vat as for calico; (2.) print-on the fat resist to preserve the blue; (3.) mandarine; (4.) clear, and brighten the orange by the boil.

3. *Orange ground, with blue and white figures.*

(1.) Print-on the resist to preserve the white; (2.) dip in the vat, rinse, and dry; (3.) ground-in the fat resist to preserve the blue; (4.) mandarine; (5.) cleanse, and brighten.

4. *Full green ground, and white figures.*

(1.) Print-on the resist; (2.) mandarine, and rinse without drying; (3.) dip in the blue vat; (4.) cleanse, and brighten.

5. *Full green ground, and blue figures.*

(1.) Dip a pale blue, rinse, and dry; (2.) print-on the fat resist; (3.) mandarine, wash and dry; (4.) dip full blue; (5.) clean, and brighten.

6. *Full green ground, with white and blue figures.*

(1.) Print on the resist; (2.) dip a pale blue, and dry; (3.) ground-in the fat resist; (4.) mandarine and rinse; (5.) dip a full blue; (6.) clean, and brighten. ·

7. *Full green ground, with white, blue, and orange figures.*

(1.) Print-on the fat reserve; (2.) dip a pale blue, and dry; (3.) ground-in the reserve; (4.) mandarine, rinse, and dry; (5.) ground-in the reserve; (6.) dip a full blue; (7.) clean, and brighten.

If blue grounds with white figures be wanted, the resist must be applied, and then the goods must be dipped in the blue vat: the resist is afterwards removed by a boil in soap-water.

The above processes are applicable to chalys.

The property which nitric acid possesses of staining animal matters yellow, such as the skin, wool, and silk, is here applied to a very elegant purpose.

Of the bronze or solitaire style by mandarining.—The mandarining mixture is 1 gallon of nitric acid, of 1·17 spec. grav.; mixed with 3 pints of solution of nitrate of iron, of spec. grav. 1·65. If the quantity of nitrate of iron be increased, a darker tint will be obtained. The temperature of the mixture should be 94° F. The pieces, after mandarining, are let fall into water, and steeped for an hour.

In order to raise the bronze, and clear away the fat resist, the goods must be boiled in a bath of soap and soda, as described for orange.

1. *Bronze ground, with white figures.*

(1.) Print-on the fat resist; (2.) dip in the blue vat, and dry; (3.) pad in a decoction of logwood, of 4 lbs. per gallon; dry, taking care to turn over the selvages; (4.) mandarine, and steep in water for an hour; (5.) cleanse, and pass through soap.

2. *Bronze ground, with blue figures.*

(1.) Dip in the blue vat, and dry; (2.) print-on the fat resist; (3.) pad in the above decoction of logwood, and dry; (4.) mandarine, and steep an hour; (5.) cleanse, and brighten.

3. *Bronze ground, with white and blue.*

(1.) Print-on the fat resist; (2.) dip in the blue vat, and dry; (3.) ground-in the fat resist; (4.) pad in the logwood liquor, and dry; (5.) mandarine, and steep for an hour; (6.) cleanse, and give the brightening boil with soap.

This style of manufacture may be executed on chalys; and is capable of producing beautiful effects, which will in vain be sought for by other means.

With silks, advantage may be derived from various metallic solutions which possess the property of staining animal substances; among which are nitrate of silver, nitrate of mercury, and muriate of iron. The solutions of these salts may be thickened with gum, and printed-on.

An orange upon an indigo vat ground.—After the blue ground has been dyed, orange figures may be produced by printing-on the following discharge paste :—

1 gallon of water, made into a paste with 1 pound of starch; when cold, add to it from 16 to 24 ounces of nitric acid, of spec. grav. 1·288. After fixing the color by steam, the orange is brightened with a soap boil.

An orange upon a Prussian-blue ground.—The dye is first given by Prussian blue in the ordinary way, and then the following discharge is printed-on :—

A caustic ley being prepared, of 1·086 specific gravity, dissolve in a gallon of it 2 pounds of annotto, and thicken with 3 pounds and a quarter of gum. Two days after the impression of this paste, pass the goods through steam, and wash them in running water. With these two designs, the logwood and gall-black, formerly described, may be associated, to produce a rich effect.

To the preceding practical instructions for printing calicoes, silks, woollens, and mixed fabrics, made of the two latter, a few annotations may be added.

When a uniform color is to be applied to both sides of the cloth, the padding process is employed; but, when only one side is to be thus colored, diagonal lines are cut very closely to each other upon the cylinder, which transfer so much color from the trough to the cloth passed under it as to make the surface appear uniformly stained. This process is called *mattage* by the French. Mordants or topical dyes, to be applied in this way, should not be much thickened.

The *doubler* is the piece of felt or blanket stuff placed between the cloth to be printed, and the block printing-table, or the cylinders. It should be kept very clean; because, were it soiled with acetate of iron, it would spoil all the light shades made with acetate of alumina.

Filters for the color shop of a print-house are best made of wool, formed into a substantial conical cap by felting. A filter ought to be set apart for each different dye-stuff.

When the goods after dyeing are washed, by being held by the selvage, dipped, and shaken in a stream of water, the process is called *giving a list* by the French (*donner une lisière*). The piece is transferred alternately from one hand to another.

Stains. When we observe stains produced by mordants upon spots where no color is to come, we must, before dunging the goods, apply a little of the lime-juice, or tartaro-oxalic acid discharge paste, to the place. If, on the contrary, the stains are not perceived till after the maddering, we must then apply to it first a strong solution of chloride of lime with a pencil, next a solution of oxalic acid mixed with a little muriatic with another pencil, and immediately afterward wash with water. Every madder stain will be effaced by this means.

Rust stains are removeable by a mixture of oxalic and muriatic acids.

Indigo stains by the combined action of chloride of lime and muriatic acid.

Topical yellow stains, or yellow dyes, by the same combination.

Metallic greens and Scheele's green by the acid alone.

Chrome green, and Prussian blue. The blue may be taken out by a caustic alkali after which the goods must be washed : the residuary rust stain may be removed by a mixture of oxalic and muriatic acids. The above methods refer to cotton and linen. The stains on silk and woollen stuffs should be removed before fixing the colors by a soap boil; which may generally be done by scratching with the finger, with the aid of a little water.

For a direct calico green, see oxyde of CHROME.

Mr. Hudson, of Gale, near Rochdale, obtained a patent, in December, 1834, for a mechanism which furnishes a continual and regular supply of color to the sieve or tear (*tire*, Fr.), into which the printer has to dip his block, for the purpose of receiving the color about to be transferred to the fabric in the operations of printing calicoes or paper hangings. The contrivance consists in a travelling endless web, moved by power, which, by passing progressively from the color vat over the diaphragm, brings forward continuously an equable supply of the colored paste for the workman's block.
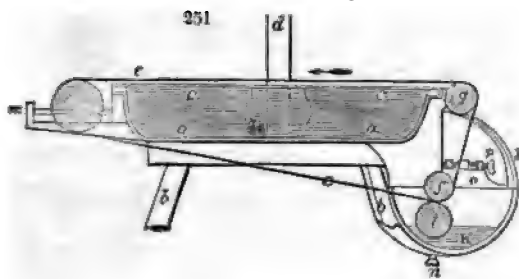
Fig. 251 represents the construction of this ingenious apparatus, shown partly in section. *a a* is a vessel of iron, supported upon wooden standards *b b*, over the upper surface of which vessel a sheet or diaphragm, *c c*, of oiled cloth, or other suitable elastic material, is distended and made fast at its edges by being bent over a flange, and packed or cemented to render the joints water-tight. A vertical pipe *d* is intended to conduct water to the interior of the vessel *a*, and, by a small elevation of the column, to create such upward pressure as shall give to the diaphragm a slight bulge like the swimming tub.

An endless web, *e e e*, passing over the surface of the diaphragm, is distended over three rollers, *f g h*, the lower of which, *f*, is in contact with the color-roller *i* in the color-trough κ. On the axle of the roller *i* a pulley wheel is fixed, which allows the roller to be turned by a band from any first mover; or the roller may receive rotatory motion by a winch fixed on its axle. On this said axle there is also a toothed wheel, taking into a another toothed wheel on the axle of the roller *f*; hence, the rotation of the color-roller *i* in the one direction will cause the roller *f* to revolve in the opposite, and to carry forward the endless web *e e e*, over the elastic diaphragm, the web taking with it a stratum of color received from the roller *i*, evenly distributed over its surface, and ready for the printer to dip his block into.

The axles of the rollers *f* and *g* turn in stationary bearings; but the axle of *h* is mounted in sliding nuts, which may be moved by turning the screws *m*, for the purpose of tightening the endless web. The axle of the color-roller *i* turns in mortises, and may be raised by screws *n* in order to bring its surface into contact with the endless web. To prevent too great a quantity of color being taken up, the endless web passes through a long slit, or parallel aperture, in a frame *o*, which acts as a scraper or doctor, and is adjustable by a screw *p*, to regulate the quantity of color carried up. The contents of the vessel *a*, and of the color-trough *k*, may be discharged when required by a cock in the bottom of each. See PAPER HANGINGS, for the *Fondu* style.

CALOMEL. (*Chlorure de Mercure*, Fr.; *Versüsstes Quecksilber*, Germ.) The mild protochloride of mercury. The manufacture of this substance upon the great scale may be performed in two ways. The cheapest and most direct consists in mixing 1½ part of pure quicksilver with 1 part of pure nitric acid, of spec. grav. from 1·2 to 1·25; and in digesting the mixture till no more metal can be dissolved, or till the liquid has assumed a yellow color. At the same time, a solution of 1 part of common salt is made in 32 parts of distilled water, to which a little muriatic acid is added; and, when heated to nearly the boiling point, it is mixed with the mercurial solution. The two salts exchange bases, and a protochloride of mercury precipitates in a white powder, which, after being digested for some time in the acidulous supernatant liquor, is to be washed with the greatest care in boiling water. The circumstances which may injure the process are the following :—1. When less mercury is employed than the acid can dissolve, there is formed a deuto-nitrate of mercury, which forms some corrosive sublimate with the common salt, and causes a proportional defalcation of calomel. 2. If the liquors are perfectly neutral at the moment of mixing them, some subnitrate of mercury is thrown down, which cannot be removed by washing, and which gives a noxious contamination to the bland calomel. The acid prescribed in the above formula obviates this danger.

The second manner of manufacturing calomel is to grind very carefully 4 parts of corrosive sublimate (bi-chloride of mercury) with 3 parts of quicksilver, adding a little water or spirits to repress the noxious dust during the trituration. The mass is then introduced into a glass globe, and sublimed at a temperature gradually raised. The quicksilver combines with the deutochloride, and converts it into the protochloride, or calomel. The

following formula, upon the same principle, was recommended to the chemical manufacturer in Brande's Journal for July, 1818:—

" Prepare an oxysulphate of mercury, by boiling 25 pounds of mercury with 35 pounds of sulphuric acid to dryness. Triturate 31 pounds of this dry salt with 20 pounds 4 ounces of mercury, until the globules disappear, and then add 17 pounds of common salt. The whole is to be thoroughly mixed, and sublimed in earthen vessels. Between 46 and 48 pounds of pure calomel are thus produced : it is to be washed and levigated in the usual way." The above is the process used at Apothecaries' Hall, London. The oxysulphate is made in an iron pot; and the sublimation is performed in earthen vessels. The crystalline crust or cake of calomel should be separated from the accompanying gray powder, which is nearest the glass, and consists of mercury mixed with corrosive sublimate.

An ingenious modification of the latter process, for which a patent, now expired, was obtained by Mr. Jewell, consists in conducting the sublimed vapors over an extensive surface of water contained in a covered cistern. The calomel thus obtained is a superior article, in an impalpable powder, propitious to its medical efficacy.

The presence of corrosive sublimate in calomel is easily detected by digesting alcohol upon it, and testing the decanted alcohol with a drop of caustic potash, when the characteristic brick-colored precipitate will fall, if any of the poisonous salt be present. To detect subnitrate of mercury in calomel, digest dilute nitric acid on it, and test the acid with potash, when a precipitate will fall in case of that contamination. As it is a medicine so extensively administered to children at a very tender age, its purity ought to be scrupulously watched.

118 parts of calomel contain 100 of quicksilver.

CALORIC. The chemical name of the power or matter of heat.

CALORIFERE OF WATER. (*Calorifère d'eau*, Fr.; *Wasser-Heitzung*, Germ.) In the *Dictionnaire Technologique*, vol. iv., published in 1823, we find the following description of this apparatus, of late years so much employed in Great Britain for heating conservatories, &c., by hot water circulating in pipes :—

" This mode of heating is analogous to that by stove-pipes : it is effected by the circulation of water, which, like air, is a bad conductor, but may serve as a carrier of caloric by its mobility. We may readily form an idea of the apparatus which has been employed for this purpose. We adapt to the upper part of either a close kettle, or of an ordinary

252
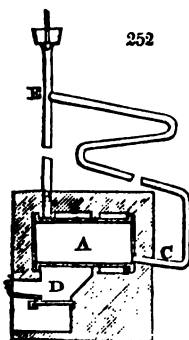
cylindric boiler A, *fig.* 252, a tube B, which rises to a certain height, then descends, making several sinuosities with a gentle slope till it reaches the level of the bottom of the boiler, to whose lowest part, as that which is least heated, it is fitted at c. At the highest point of the tube F we adapt a vertical pipe, destined to serve as an outlet to the steam which may be formed if the temperature be too much raised : it serves also for the escape of the air expelled from the water by the heat : and it permits the boiler to be replenished from time to time as the water is dissipated by evaporation; lastly, it is a tube of safety.

" The apparatus being thus arranged, and all the tubes as well as the boiler filled with water, if we kindle fire in the grate D, the first portions of water heated, having become specifically lighter, will tend to rise : they will actually mount into the upper part of the boiler, and, of course, enter the tube B F: at the same time an equivalent quantity of water will re-enter the boiler by the other extremity c of the tube. We perceive that these simultaneous movements will determine a circulation in the whole mass of the liquid, which will continue as long as heat is generated in the fireplace ; and if we suppose that the tubes, throughout their different windings, are applied against the walls of a chamber, or a stove-room, the air will get warmed by contact with the hot surfaces ; and we may accelerate the warming by multiplying these contacts in the mode indicated.

" This *calorifère* cannot be employed so usefully as those with heated air, when it is wished to heat large apartments. In fact, the passage of heat through metallic plates is in the ratio of the difference of temperature and quantity of the heating surfaces. In the present case, the temperature of the water, without pressure, in the tubes, must be always under 100° C. (212° F.), even in those points where it is most heated, and less still in all the other points, while the temperature of the flues in *air stoves*, heated directly by the products of combustion, may be greatly higher. In these stoves, also, the pipes may without inconvenience have a large diameter, and present, consequently, a large heating surface; whereas, with the water *calorifère*, the pressure exercised by the liquid upon the sides of the tubes being in the ratio of the surfaces, we are obliged, in order to avoid too great pressure, to employ a multitude of small tubes, which is expensive. Lastly, if

the hot-water circulation is to be carried high, as may be often necessary in lofty build-ings, the pressure resulting from the great elevation would call for proportional thickness in the tubes and the boiler: for these reasons, and others which we shall state in treating of heating by steam, it appears that water cannot be advantageously substituted for air or steam in the applications above stated; yet this mode of heating presents very decided advantages where it is useful to raise the temperature a small number of degrees in a uniform manner." See INCUBATION, ARTIFICIAL.

"M. Bonnemain applied, with much success, these ingenious processes of heating by the circulation of water, to maintain a very equal temperature in hot-houses (serres-chaudes), in stoves adapted to artificial incubation, and in preserving or quickening vege-tation within hot-houses, or outside of their walls, during seasons unpropitious to horti-culture.

"Since the capacity of water for heat is very great, if the mass of it in a circulation-apparatus be very considerable, and the circulation be accelerated by proper arrangements, as by cooling the descending tube exterior to the stove-room, we may easily obtain by such means a moderately high and uniform temperature, provided the heat generated in the fire-place be tolerably regular. We may easily secure this essential point by the aid of the *fire-regulator*, an instrument invented by M. Bonnemain, and which is described un-der the article INCUBATION, because there its use seems to be indispensable."

From the above quotation, and, more especially, from the evidence adduced in the ar-ticle INCUBATION, we see how little claim the Marquis de Chabannes, or any of his fol-lowers, can have to invention in their arrangements for heating apartments by the calorific motions of the particles of water, enclosed in pipes of any kind.

CAMBRIC. (*Batiste*, Fr.; *Kammertuch*, Germ.) A sort of very fine and rather thin linen fabric, first made at Cambray. An excellent imitation of this fabric is made in Lancashire, woven from fine cotton yarn hard twisted. Linen cambric of a good quality is also now manufactured in the United Kingdom from power-spun flax.

CAMLET, or CAMBLET. A light stuff, much used for female apparel. It is made of long wool hard spun, sometimes mixed in the loom with cotton or linen yarn.

CAMPHOR, or CAMPHIRE. This immediate product of vegetation was known to the Arabs under the names of *kamphur* and *kaphur*, whence the Greek and Latin name *camphora*. It is found in a great many plants, and is secreted, in purity, by several lau-rels; it occurs combined with the essential oils of many of the *labiacæ*; but it is extract-ed, for manufacturing purposes only, from the *Laurus camphora*, which abounds in China and Japan, as well as from a tree which grows in Sumatra and Borneo, called, in the country, *Kapour barros*, from the name of the place where it is most common. The cam-phor exists, ready formed, in these vegetables, between the wood and the bark; but it does not exude spontaneously. On cleaving the tree *Laurus sumatrensis*, masses of pure camphor are found in the pith.

The wood of the laurus is cut into small pieces, and put, with plenty of water, into large iron boilers, which are covered with an earthen capital or dome, lined within with rice straw. As the water boils, the camphor rises with the steam, and attaches itself as a sublimate to the stalks, under the form of granulations of a gray color. In this state, it is picked off the straw, and packed up for exportation to Europe.

Formerly Venice held the monopoly of refining camphor, but now France, England, Holland, and Germany refine it for their own markets. All the purifying processes pro-ceed on the principle that camphor is volatile at the temperature of 400° F. The sub-stance is mixed, as intimately as possible, with 2 per cent. of quicklime, and the mixture is introduced into a large bottle made of thin uniform glass, sunk in a sand bath. The fire is slowly raised till the whole vessel becomes heated, and then its upper part is gradu-ally laid bare in proportion as the sublimation goes on. Much attention and experience are required to make this operation succeed. If the temperature be raised too slowly, the neck of the bottle might be filled with camphor before the heat had acquired the proper subliming pitch; and, if too quickly, the whole contents might be exploded. If the operation be carried on languidly, and the heat of the upper part of the bottle be somewhat under the melting point of camphor, that is to say, a little under 350° F., the condensed camphor would be snowy, and not sufficiently compact and transparent to be saleable. Occasionally, sudden alternations of temperature cause little jets to be thrown up out of the liquid camphor at the bottom upon the cake formed above, which soil it, and render its re-sublimation necessary.

If, to the mixture of 100 parts of crude camphor and 2 of quicklime, 2 parts of bone-black, in fine powder, be added, the small quantity of coloring matter in the camphor will be retained at the bottom, and whiter cakes will be produced. A spiral slip of pla-tina foil immersed in the liquid may tend to equalize its ebullition.

By exposing some volatile oils to spontaneous evaporation, at the heat of about 70° F., Proust obtained a residuum of camphor; from oil of lavender, 25 per cent. of its weight; from oil of sage, 12½; from oil of marjoram, 10.

Refined camphor is a white translucid solid, possessing a peculiar taste and smell. It may be obtained, from the slow cooling of its alcoholic solution, in octahedral crystals. It may be scratched by the nail, is very flexible, and can be reduced into powder merely by mixing it with a few drops of alcohol. Its specific gravity varies from 0·985 to 0·996. Mixed and distilled with six times its weight of clay, it is decomposed, and yields a golden yellow aromatic oil, which has a flavor analogous to that of a mixture of thyme and rosemary; along with a small quantity of acidulous water tinged with that oil, charcoal remains in the retort. In the air, camphor takes fire on contact of an ignited body, and burns all away with a bright fuliginous flame.

Camphor is little soluble in water; one part being capable of communicating smell and taste to 1000 of the fluid. 100 parts of alcohol, spec. grav. 0·806, dissolve 120 parts of camphor, at ordinary temperatures. It is separated in a pulverulent state, by water. Ether and oils, both expressed and volatile, also dissolve it.

When distilled with eight parts of aquafortis, camphor is converted into camphoric acid. Camphor absorbs 144 times its volume of muriatic acid gas, and is transformed into a colorless transparent liquid, which becomes solid in the air, because the acid attracts humidity, which precipitates the camphor. One part of strong acetic acid dissolves two parts of camphor. By my analysis, camphor consists of 77·38 carbon, 11·14 hydrogen, and 11·48 oxygen. Berzelius's numbers are certainly erroneous.

CAMWOOD. An article imported from Sierra Leone, which seems to possess similar dyeing powers with Brazil or Nicaragua wood.

CANDLE. (*Chandelle*, Fr.; *Kerze, Licht*, Germ.) I shall first briefly describe the ordinary manufacture of candles. They are either dipped or moulded. But the first part of the process is the sorting of the tallow. Mutton suet with a proportion of ox-tallow is selected for mould candles, because it gives them gloss and consistence. Coarser tallow is reserved for the dipped candles. After being sorted, it is cut into small pieces, preparatory to being melted or *rendered*; and the sooner this is done after the fat is taken from the carcass the better, because the fibrous and fleshy matters mixed with it promote its putrefaction. Tallow is too commonly melted by a naked fire applied to the bottom of the vessel, whereas it should be done either in a cold set pan, where the flame plays only round the sides a little way above the bottom, or in a steam-cased pan. After being fused a considerable time, the membraneous matters collect at the surface, constituting the *cracklings* used sometimes for feeding dogs, after the fat has been squeezed out of it by a press. The liquid tallow is strained through a sieve into another copper, where it is treated with water at a boiling temperature in order to wash it. After a while, when the foul water has settled to the bottom, the purified tallow is lifted out, by means of tinned iron buckets, into tubs of a moderate size, where it concretes, and is ready for use.

It is a remarkable circumstance, that the wicks for the best candles are still cotton rovings imported from Turkey, notwithstanding the vast extension and perfection of cotton-spinning in this country. Four or more of these Turkey skeins, according to the intended thickness of the wick, are wound off at once into bottoms or clews, and afterward cut by a simple machine into lengths corresponding to those of the candles to be made. Mr. Colebank obtained a patent, in June, 1822, for a machine for cutting, twisting, and spreading wicks, which, though convenient, does not seem to have come into general use. The operations are performed upon a series of threads at once. The apparatus is placed in a box, in front of which the operator sits. A reel extends across the box, at the hinder part, upon which the cotton threads have been previously wound: from this reel they are drawn off in proper lengths, doubled, and cut by an ingenious mechanism. By dipping the wicks into the melted tallow, rubbing them between the palms of the hands, and allowing the tallow which adheres to harden, they may be arranged with facility upon the broaches for the purpose of dipping. The dipping-room is furnished with a boiler for melting the tallow, the dipping-mould, or cistern, and a large wheel for supporting the broaches. From the ceiling of the workshop a long balance-shaped beam is suspended, to one end of which a wooden frame is attached for holding the broaches with the wicks arranged at proper distances. The opposite arm is loaded with a weight to counterbalance the wooden frame, and to enable the workman to ascertain the proper size of the candles. The end of the lever which supports the frame is placed immediately above the dipping-cistern; and the whole machine is so balanced that, by a gentle pressure of the hand, the wicks are let down into the melted tallow as often as may be required.

The following convenient apparatus for dipping candles has been long in use at Edinburgh. In the centre of the dipping-room a strong upright post A A, *fig.* 253, is erected, with turning iron pivots at its two ends. Near its middle, six mortises are cut at small distances from one another, into each of which is inserted a long bar of wood B B, which moves vertically upon an iron pin, also passing through the middle of the shaft. The whole presents the appearance of a large horizontal wheel with twelve arms. A complete

view of two of them only is given in the figure. From the extremity of each arm is suspended a frame, or port, as the workmen call it, containing 6 rods, on each of which are hung 18 wicks, making the whole number of wicks upon the wheel 1296. The machine, though apparently heavy, turns round by the smallest effort of the workman; and each port, as it comes in succession over the dipping-mould, is gently pressed downwards, by which means the wicks are regularly immersed in melted tallow. As the arms of the lever are all of the same length, and as each is loaded with nearly the same weight, it is obvious that they will all naturally assume a horizontal position. In order, however, to prevent any oscillation of the machine in turning round, the levers are kept in a horizontal position by means of small chains *a a*, one end of which is fixed to the top of the upright shaft, and the other terminates in a small square piece of wood, *b*, which exactly fills the notch *c* in the lever. As one end of the levers must be depressed at each dip, the square piece of wood is thrown out of the notch by the workman pressing down the handle D, which communicates with the small lever *e*, inserted into a groove in the bar B. In order that the square piece of wood, fixed in one extremity of the chain, may recover its position upon the workman's raising the port, a small cord is attached to it, which passes over a pulley inserted in a groove near *c*, and communicates with another pulley and weight, which draws it forward to the notch. In this way the operation of dipping may be conducted by a single workman with perfect ease and regularity, and even despatch. No time is lost, and no unnecessary labor expended, in removing the ports after each dip; and, besides, the process of cooling is much accelerated by the candles being kept in constant motion through the air. The number of revolutions which the wheel must make, in order to complete one operation, must obviously depend upon the state of the weather and the size of the candles; but it is said that, in moderately cold weather, not more than two hours are necessary for a single person to finish one wheel of candles of a common size. Upon the supposition, therefore, that six wheels are completed in one day, no less a number than 7776 candles will be manufactured in that space of time by one workman.

I shall next describe the process of moulding, which, if possible, is even less complicated in its details than that of dipping. The moulds are made of some metallic substance, usually pewter, and consist of two parts. The shaft or great body of the mould is a hollow cylinder, finely polished in the inside, and open at both extremities. The top of the mould is a small metallic cup, having a moulding within-side, and a hole to admit the wick. The two parts are soldered together, and when united, as will readily be imagined, have the shape of a moulded candle. A third piece, called the foot, is sometimes added: it is a kind of small funnel, through which the liquid tallow runs into the mould, and, being screwed to the opposite extremity of the shaft, is removeable at pleasure. This additional piece may certainly be useful in very mild weather, since, by removing it, the candles may be drawn more easily from the moulds; but, in general, it may be dispensed with.

Eight or twelve of these moulds, according to their size, are fixed in a frame, which bears a great resemblance to a wooden stool, the upper surface of which forms a kind of trough. The top of the moulds points downwards, and the other extremity, which is open, is inserted into the bottom trough or top of the stool, and made quite level with its upper surface. In order to introduce the wicks into the mould, the workman lays the frame upon its side on an adjoining table, and holding in his left hand a quantity of wicks, previously cut to the proper length, he introduces into the mould a long wire with a hooked point. As soon as the hook of the wire appears through the hole in the top of the mould, he attaches to it the looped end of the wick, and, immediately drawing back the wire, carries the wick along with it. In this manner each mould in succession is furnished with a wick. Another workman now follows, and passes a small wire through the loop of each wick. This wire is obviously intended to keep the wick stretched, and to prevent it from falling back into the mould upon the frame being placed in the proper position for filling. The frame is then handed to the person that fills the moulds, who

previously arranges the small wires in such a manner that each wick may be exactly in the middle of the mould.

The moulds are filled by running tallow into each of them, or into the trough, from a cistern furnished with a cock, and which is regularly supplied with tallow of the proper temperature from an adjoining boiler. When the workman observes that the moulds are nearly half filled he turns the cock, and, laying hold of that portion of the wick which hangs out of the mould, pulls it tight, and thus prevents any curling of the wick, which might injure the candles: he then opens the cock, and completes the process of filling. The frame is now set aside to cool; and when the tallow has acquired a proper consistence, which the workman easily discovers by a snapping noise emitted by the candles upon pressing his thumb against the bottom of the moulds, he first withdraws the small wires which kept the wicks tense, and then, scraping off the loose tallow from the top of the frame with a small wooden spade, he introduces a bodkin into the loop of the wick, and thus draws each candle in succession from its mould. The candles are now laid upon a table for the inspection of the exciseman, and afterwards removed to the storehouse. Previous to storing them up, some candle-makers bleach their candles, by exposing them to the air and dews for several days. This additional labor can be necessary only when the dealer is obliged to have early sales; for if the candles are kept for some months, as they ought to be, before they are brought to market, they become sufficiently whitened by age.

Wax candles.—Next to tallow, the substance most employed in the manufacture of candles is wax. Wax candles are made either by the hand or with a ladle. In the former case, the wax, being kept soft in hot water, is applied bit by bit to the wick, which is hung from a hook in the wall; in the latter, the wicks are hung round an iron circle, placed immediately over a large copper-tinned basin full of melted wax, which is poured upon their tops, one after another, by means of a large ladle. When the candles have by either process acquired the proper size, they are taken from the hooks, and rolled upon a table, usually of walnut-tree, with a long square instrument of box, smooth at the bottom.

A few years ago I made a set of experiments upon the relative intensities of light, and duration of different candles, the results of which are contained in the following table.

Number in a pound.	Duration of a candle.		Weight in grains.	Consumption per hour in grains.	Proportion of light.	Economy of light.	Candles equal one Argand.
	h.	*m.*					
10 mould - - -	5	9	682	132	12¼	68	5·7
10 dipped - -	4	36	672	150	13	65½	5·25
8 mould - - -	6	31	856	132	10½	59¼	6·6
6 ditto - - -	7	2½	1160	163	14⅝	66	5·0
4 ditto - - -	9	3·6	1707	186	20¼	80	3·5
Argand oil flame	—		—	512	69·4	100	

A Scotch mutchkin, or ⅛ of a gallon of good seal oil, weighs 6010 gr., or $13\frac{1}{10}$ oz., avoirdupois, and lasts in a bright Argand lamp 11 hours 44 minutes. The weight of oil it consumes per hour is equal to 4 times the weight of tallow in candles 8 to the pound, and ⅐ the weight of tallow in candles 6 to the pound. But, its light being equal to that of 5 of the latter candles, it appears from the above table that 2 pounds weight of oil, value 9*d*. in an Argand, are equivalent in illuminating power to 3 pounds of tallow candles, which cost about two shillings. The larger the flame in the above candles the greater the economy of light.

In June, 1825, M. Gay Lussac obtained a patent in England for making candles from *margaric and stearic acids*, improperly called *stearine*, by converting tallow into the above fat acids by the following process :—Tallow consists, by Chevreul's researches, of stearine, a solid fat, and elaine, a liquid fat; the former being in much the larger proportion. When tallow is treated with an alkaline body, such as potash, soda, or lime, it is saponified; that is, its stearine and elaine become respectively stearic and elaic acids, and, as such, form compounds with these bases. When by the action of an acid, such as the sulphuric or muriatic, these combinations are decomposed, the fats reappear in the altered form of stearic and elaic acids; the former body being harder than tallow, and of a texture somewhat like spermaceti, the latter body being fluid, like oil. "The decomposition of the soap should be made," says the patentee, "in a large quantity of water, kept well stirred during the operation, and warmed by steam introduced in any convenient way. When the mixture has been allowed to stand, the acid of the tallow or fat will rise to the surface, and the water being drawn off will carry the alkaline or saline matters with it; but if the acids of the tallow should retain any portion of the salts, fresh water may be

thrown upon it, and the whole well agitated, until the acids have become perfectly free from the alkaline matters; and, when allowed to cool, the acids will be formed into a solid mass. This mass is now to be submitted to considerable pressure in such an apparatus as is employed in expressing oil from seeds; when the liquid acid will run off in the form of a substance resembling oil, leaving a solid matter, similar, in every respect, to spermaceti, which is fit for making candles.

The wick to be used in the manufacture of these improved candles, and which forms one of the features of this invention, is to be made of cotton yarn, twisted rather hard, and laid in the same manner as wire is sometimes coiled round the bass strings of musical instruments. For this purpose, straight rods or wires are to be procured, of suitable lengths and diameters, according to the intended size of the candles about to be made; and these wires, having been covered with cotton coiled round them as described, are to be inserted in the candle-moulds as the common wicks are; and when the candle is made, and perfectly hard, the wire is to be withdrawn, leaving a hollow cylindrical aperture entirely through the middle of the candle. See STEARINE.

CANE-MILL. See MILL and SUGAR.

CANNON. For the composition of these implements of destruction, see BRONZE.

CANVASS. (Cancras, Fr.; Segeltuch, Germ.) It has been found that sails of ships made with the selvages and seams of the canvass running down parallel to their edges, are very apt to bag, and become torn in the middle, from the strain to which they are subjected by the pressure of the wind. To obviate this inconvenience, a mode of making sails, with the seams and selvages running diagonally, was proposed by Admiral Brooking, and a patent granted to him for the same on the 4th of September, 1828. The invention of Messrs. Ramsay and Orr, which we are about to describe, has a similar object, viz., that of giving additional strength to sails by a peculiar manner of weaving the canvass of which they are made.

The improvement proposed under their patent of March, 1830, consists in weaving the canvass with diagonal threads; that is, placing the weft yarn, or shoot, in weaving, at an oblique angle to the warp yarns, instead of making the decussation of the warp, or weft threads, or yarns, at right angles to each other, as in the ordinary mode of weaving.

To accomplish this object, the loom must be peculiarly constructed; that is, its warp and work beams must stand at an oblique angle with the sides of the loom, and the batten and slay must be hung in a peculiar manner, in order to beat up the weft, or shoot, in lines rnazing diagonally with the warp. No drawing is shown of the method by which this arrangement of the loom is to be made, but it is presumed that any weaver would know how to accomplish it: the invention consisting solely in producing sail-cloth with the threads or yarns of the weft ranging diagonally at any desired angle with the direction of the warp thread.

CAOUTCHOUC, GUM-ELASTIC, OR INDIAN-RUBBER (Federharz, Germ.), occurs as a milky juice in several plants, such as the siphonia cahuca, called also herea guienensis, cautschuc, jatropha elastica, castilleja elastica, cecropia pellata, ficus religiosa and vadica, urceolaria elastica, &c. It is, however, extracted chiefly from the first plant, which grows in South America and Java. The tree has incisions made into it through the bark in many places, and it discharges the milky juice, which is spread upon clay moulds, and dried in the sun, or with the smoke of a fire, which blackens it.

The juice itself has been of late years imported. It is of a pale yellow color, and has the consistence of cream. It becomes covered, in the bottles containing it, with a pellicle of concrete caoutchouc. Its spec. grav. is 1·012. When it is dried, it loses 55 per cent. of its weight: the residuary 45 is elastic gum. When the juice is heated, it immediately coagulates, in virtue of its albumen, and the elastic gum rises to the surface. It mixes with water in any proportion; and, when thus diluted, it coagulates with heat and alcohol as before.

The specific gravity of caoutchouc is 0·925, and it is not permanently increased by any degree of pressure. By cold or long quiescence, it becomes hard and stiff. When the milky juice has become once coherent, no means hitherto known can restore it to the emulsive state. By long boiling in water it softens, swells, and becomes more readily soluble in its peculiar menstrua; but when exposed to the air, it speedily resumes its pristine consistence and volume. It is quite insoluble in alcohol; but in ether, deprived of alcohol by washing with water, it readily dissolves, and affords a colorless solution. When the ether is evaporated, the caoutchouc becomes again solid, but is somewhat clammy for a while. When treated with hot naphtha, distilled from native petroleum, or from coal tar, it swells to 30 times its former bulk; and if then triturated with a pestle, and pressed through a sieve, it affords a homogeneous varnish, which being applied by a flat edge of metal or wood to cloth, prepares it for forming the patent water-proof cloth of Mackintosh. Two surfaces of cloth, to which several coats of the above varnish have been applied, are, when partially dried, brought evenly in contact, and then passed between rollers, in order to condense and smooth them together. This double

cloth is afterwards suspended in a stove-room to dry, and to discharge the disagreeable odor of the naptha.

Caoutchouc dissolves in the fixed oils, such as linseed oil, but the varnish has not the property of becoming concrete upon exposure to air.

It has been lately asserted that caoutchouc is soluble in the oils of lavender and sassafras.

It melts at 248° F., and stands afterwards a much higher heat without undergoing any further change. When the melted caoutchouc is exposed to the air, it becomes hard on the surface in the course of a year. When kindled it burns with a bright flame and a great deal of smoke.

Neither chlorine, sulphurous acid gas, muriatic acid gas, ammonia, nor fluosilicic acid gas affects it, whence it forms very valuable flexible tubes for pneumatic chemistry. Cold sulphuric acid does not readily decompose it, nor does nitric acid, unless it be somewhat strong. The strongest caustic potash ley does not dissolve it even at a boiling heat.

Caoutchouc, according to my experiments, which have been confirmed by those of Mr. Faraday, contains no oxygen, as almost all other solid vegetable products do, but is a mere compound of carbon and hydrogen, in the proportion, by my results, of 90 carbon to 10 hydrogen, being three atoms of the former to two of the latter. Mr. Faraday obtained only 87·2 carbon, from which I would infer that some of the carbon, which in this substance is difficult to acidify by peroxyde of copper, had escaped its action. It is obvious that too little carbonic acid gas may be obtained, but certainly not more than corresponds to the carbon in the body. No carbon can be created in the process of ultimate analysis by pure peroxyde of copper such as I employed; and I repeated the ignition after attrition of the mixture used in the experiment. Melted caoutchouc forms a very excellent chemical lute, as it adheres very readily to glass vessels, and withstands the corrosive action of acid vapors. This substance is much used for effacing the traces of plumbago pencils, whence it derived the name of Indian-rubber. It has been lately employed very extensively for making elastic bands or braces. The caoutchouc bottles are skilfully cut into long spiral slips, which are stretched, and kept extended till nearly deprived of their elasticity, and till they form a thread of moderate fineness. This thread is put into a braid machine, and covered with a sheath of cotton, silk, linen, or worsted. The clothed caoutchouc is then laid as warp in a loom, and woven into an elegant riband. When woven, it is exposed upon a table to the action of a hot smoothing iron, which restoring to the caoutchouc all its primitive elasticity, the riband retracts considerably in length, and the braiding corrugates equally upon the caoutchouc cores. Such bands possess a remarkable elasticity, combined with any desired degree of softness. Sometimes cloth is made of these braided strands of caoutchouc used both as warp and as weft, which is therefore elastic in all directions. When a light fabric is required, the strands of caoutchouc, either naked or braided, are alternated with common warp yarns. For this mixed fabric a patent has been obtained. The original manufacturer of these elastic webs is a major in the Austrian service, who has erected a great factory for them at St. Denys, near Paris. See ELASTIC BANDS.

Mr. William Henry Barnard, in the course of some experiments upon the impregnation of ropes with caoutchouc, at the factory of Messrs. Enderby, at Greenwich, discovered that

when this substance was exposed to a heat of about 600° F. it resolved itself into a vapor, which, by proper refrigeratory methods, was condensable into a liquid possessing very remarkable properties, to which the name caoutchoucine has been given. For this invention "of a solvent not hitherto used in the arts" Mr. Barnard obtained a patent, in August, 1833. His process for preparing it is described in his specification as follows:—I take a mass of the said caoutchouc, or Indian rubber, as imported, and having cut it into small lumps, containing about two cubic inches each (which I prefer), I throw these lumps into a cast-iron still (which I find adapted for the purpose, and a diagram of which is annexed to, and forms part of, this my specification), with a worm attached; *fig.* 254, A is the still, B the cover ground to a metallic

it of a thermometer to take the temperature; c the fire-place, D the ash-pit, m-tub and worm, F the brick-work of the still, G a roller and carriage, in 1 with a crane, or other means, to raise the cover to take out the residue, and he same; H the chain.

pply heat to the still in the usual manner, which heat is increased until the er ranges at 600 degrees of Fahrenheit, or thereabouts. And as the ther-anges progressively upwards to 600 degrees of Fahrenheit, a dark-colored oil is distilled over, which I claim as my said invention, such liquid being a caoutchouc, and other resinous and oleaginous substances. When the ther-eaches 600 degrees, or thereabouts, nothing is left in the still but dirt and

ound the operation of distillation to be facilitated by the addition of a portion either previous or subsequent to rectification, as hereinafter mentioned, in the of one third of oil to two thirds of caoutchouc.

ards subject the dark-colored liquid thus distilled to the ordinary process of o, and thereby obtain fluids varying in specific gravity, of which the lightest is not been under 670, taking distilled water at 1000, which fluids I also claim invention.

rectification the color of the liquid becomes more bright and transparent, until, ific gravity of 680, or thereabouts, it is colorless and highly volatile.

rocess of rectification (for the purpose of obtaining a larger product of the oil put about one third of water into the still. In each and every state the solvent of caoutchouc, and several resinous and oleaginous substances, and er substances (such as copal), in combination with very strong alcohol.

experienced much difficulty in removing the dirt which adheres to the bottom I throw into the still lead and tin in a state of alloy (commonly called solder), h of about half an inch, and, as this becomes fused, the dirt which lies on the it is more easily removed.

as have been made to the smell of this liquid: I have found such smell re-nixing and shaking up the liquid with nitro-muriatic acid, or chlorine, in the of a quarter of a pint of the acid (of the usual commercial strength) to a he liquid.

overy of the chemical solvent, which forms the subject of the patent above as excited considerable interest in the philosophic world, not only from its sefulness as a new article of commerce, but also from two very extraordinary ties which it is found to possess, viz., that, in a liquid state, it has less specific in any other liquid known to chemists, being considerably lighter than sul-r, and, in a state of vapor, is heavier than the most ponderous of the gases. entary constituents are,

| Carbon | - | - | - | - | 6·812 | - | - | - | 8 proportions. |
| Hydrogen | - | - | - | - | 1·000 | - | - | - | 7 ditto. |

r material (when mixed with alcohol) is a solvent of all the resins, and particu-al, which it dissolves, without artificial heat, at the ordinary temperature of here; a property possessed by no other solvent known; and hence it is pecu-l for making varnishes in general. It also mixes readily with oils, and will be a valuable and cheap menstruum for liquefying oil-paints; and, without in t degree affecting the most delicate colors, will, from its ready evaporation, aint to dry almost instantly.

it oil, at the common temperature of the atmosphere, always assumes a con-but a portion of this caoutchoucine mixed with it will cause the oil to become to retain sufficient fluidity to burn in a common lamp with extraordinary

ucine is extremely volatile; and yet its vapor is so exceedingly heavy, that oured, without the liquor, from one vessel into another like water.

i. The caper is a small prickly shrub, cultivated in Spain, Italy, and the ovinces of France. The flowers are large roses of a pretty appearance, but buds alone are the objects of this cultivation.

plucked before they open, and thrown into strong vinegar slightly salted, are pickled. The crop of each day is added to the same vinegar tub, so that, se of the six months during which the caper shrub flowers, the vessel gets s sold to persons who sort the capers (the smallest being most valued) by pper sieves. This metal is attacked by the acid, wherefrom the fruit acquires or, much admired by *ignorant connoisseurs.*

rs, as found in the French market, are distinguished into five sorts; the non-capucine, the capote, the *second,* and the *third;* this being the decreasing eir quality, which depends upon the strength of the vinegar used in pickling to the size and color of the buds.

The caper shrub grows in the driest situations, even upon walls, and does not disdain any soil; but it loves a hot and sheltered exposure. It is multiplied by grafts made in autumn, as also by slips of the roots taken off in spring.

CAPSTAN. (*Cabestan*, Fr.; *Spille*, Germ.) A machine whereon the cable is wound successively in weighing the anchor of a vessel. It is a species of wheel and axle; the axle being vertical, and pierced with holes near its top for the insertion of the ends of horizontal levers, called handspikes, which represent the wheel. These are turned by the force of men moving in a circle. The power applied to the lever is to the resistance to be overcome (the weight of the anchor, for example), when the forces are in equilibrio, as the radius of the cylinder round which the cable is coiled is to the circumference described by the power.

It is manifest that the radius of the axle must be augmented in this computation by half the diameter of the cable, which is supposed to lie always one coil thick upon it. The force of a man, thus applied, has been commonly estimated as equal to the traction of 27 pounds hanging over a pulley.

Friction being so variable a quantity in capstans, renders the exact calculation of its mechanical effect somewhat uncertain.

A stout man, stationed near the bottom of the axle, holds fast the loose part of the cable, which has already made two or three turns; and, being aided by its friction upon the wood, he both prevents it from slipping backwards, and uncoils each turn as it is progressively made.

Mr. Hindmarsh, master mariner of Newcastle, obtained a patent, in February, 1827, for a contrivance to enable a capstan or windlass to be occasionally worked with increased mechanical advantage. With this view, he placed toothed wheel-work, partly in the drum-head of the capstan, and partly in the upper part of the barrel, upon which the cable is coiled and uncoiled in successive portions.

The drum-head, and also the barrel, turn loosely upon a central spindle, independent of each other, and are connected together either by the toothed gear, or by bolts. On raising or withdrawing the connecting pinion from the toothed wheels, and then locking the drum-head and barrel together, the capstan works with a power equal only to that exerted by the men at the capstan-bars, as an ordinary capstan; but on lowering the pinion into gear with the wheel-work, and withdrawing the bolts which locked the drum-head to the barrel, the power exerted by the men becomes increased in proportion to the diameter and numbers of teeth in the wheels and pinions.

Fig. 255 is the external appearance of this capstan. *Fig.* 256 a horizontal view of the toothed gear at the top of the barrel. The barrel, with the whelps *a a*, turns loosely upon a vertical spindle fixed into the deck of the vessel. The drum-head *b* also turns loosely upon the same spindle. The circular frame *c c*, in *fig.* 256, in which the axes of the toothed wheels *d d d* are mounted, is fixed to the central spindle. The rim *e e e*, with internal teeth, is made fast to the top of the barrel; and the pinion *f*, which slides upon the spindle, is connected to the drum-head.
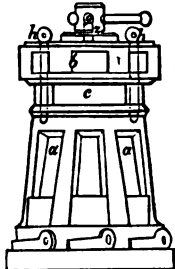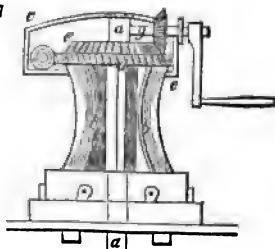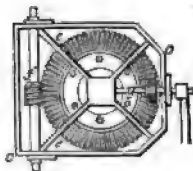
When it is intended to work the capstan with ordinary power, the pinion *f* is raised up into the recess of the drum-head, by means of a screw *g*, *fig.* 255, which throws it out of gear with the toothed wheels, and it is then locked up by a pin *z*: the bolts *h h* are now introduced, for the purpose of fastening the drum-head and barrel together, when it becomes an ordinary capstan.

256   257

255

258

But when it is required that the same number of men shall exert a greater power, the bolts *h* are withdrawn, and the pinion *f* lowered into gear with the toothed wheels. The rotation of the drum-head, then carrying the pinion round, causes it to drive the toothed wheels *d d d*; and these working into the toothed rim *e e*, attached to the barrel, cause the barrel to revolve with an increased power.

Thus, under particular circumstances, a smaller number of men at the capstan or

windlass (which is to be constructed upon the same principle) will be enabled to haul in the cable and anchor, or warp off the vessel, which is an important object to be effected.

In 1819, Captain Phillips obtained a patent for certain improvements in capstans, a part of which invention is precisely the same as this in principle, though slightly varied in its adaptation.

James Brown, ship-rigger, in his capstan, patented in 1833, instead of applying the moving power by handspikes, having fixed two rims of teeth round the top of the capstan, acts upon them by a rotatory worm, or pinions turned by a winch.

Fig. 257 is an elevation of this capstan, and *fig.* 258 is a horizontal top view : *a* is an upright shaft, fixed firmly to the deck, serving as an axle round which the body of the capstan revolves. A frame *c*, fixed to the top of a stationary shaft *a*, above the body of the capstan, carries the driving apparatus.

The upper part of the body of the capstan has a ring of oblique teeth *d* formed round its edge; and above this, on the top of the capstan, is a ring of bevel teeth *e*. A horizontal shaft *f*, mounted in the top frame *c*, has a worm or endless screw, which takes into the teeth of the ring *d*; and a short axle *g*, having its bearings in the central shaft *a*, and in the frame *c*, carries a bevel pinion, which takes into the bevel teeth of the ring *e*.

The bearings of the shaft *f*, in the top frame, are in long slots, with angular returns, something like the fastening of a bayonet, which is for the purpose of enabling the shaft to be readily lifted in and out of gear with the teeth of the ring *d* : the outer bearing of the axle *g* of the bevel pinion is also supported in the frame *c*, in a similar way, in order to put it in and out of gear with the teeth of the bevel ring *e*. A mode of shifting these is essential; because the two toothed rings, and their driving worm and pinion, give different speeds, and, of course, cannot be both in operation at the same time.

The worm of the shaft *f*, being placed in gear with the teeth of the ring *d*, on applying rotatory power thereto, by means of winches attached to the ends of the shaft, the barrel or body of the capstan will be made to revolve with a slow motion, but with great power; and thus two men at the winches will do the same work as many men with capstan bars in the ordinary way.

If a quicker movement than that of the endless screw is desired, then the driving power may be applied by a winch to the axle *g* of the bevel pinion, that pinion being put into gear with the bevel ring *e*, and the endless screw withdrawn. It should, however, be here remarked, that the patentee proposes to employ two short axles *g*, placed opposite to each other, with bevel pinions acting in the bevel-toothed ring, though only one is shown in the figure, to avoid confusion. He also contemplates a modification of the same contrivance, in which four short axles *g*, placed at right angles, with pinions taking into a bevel ring, may be employed, and made effective in giving rotatory motion to the barrel of a capstan by means of winches applied to the outer ends of the axle, and turned by the labor of four men.

CARAT, or CARACT, is a weight used by goldsmiths and jewellers. See ASSAY and DIAMOND.

CARBON (*Carbone*, Fr.; *Kohlenstoff*, Germ.), in a perfectly pure state, constitutes diamond. Carbonaceous substances are usually more or less compound, containing hydrogen, or sometimes oxygen, and azote, along with earthy and metallic matters. Carbon, tolerably pure, abounds in the mineral kingdom; and, in a combined state, it forms a main constituent of vegetable and animal bodies. Anthracite is a mineral charcoal, differing from common pit-coal in containing no bitumen, and therefore burning without flame or smoke. *Coke* is the carbonaceous mass which remains after pit-coal has been exposed to ignition for some time out of contact of air; its volatile parts having been dissipated by the heat. It is a spongy substance, of an iron-black color, a somewhat metallic lustre, and does not easily burn unless several pieces are kindled together. With a good draught, however, it produces a most intense heat. *Wood charcoal* is obtained by the calcination of wood in close vessels, as described under the article ACETIC ACID, or in piles of various shapes, covered with loam, to screen it from the free action of the atmosphere, which would otherwise consume it entirely. See CHARCOAL. Such carbon is a solid, without smell or taste, and bears the strongest heats of our furnaces without suffering any change, provided air be excluded : it is a bad conductor of heat, but conducts electricity very well. When burned, it unites with oxygen, and forms carbonic acid, the fixed air of Dr. Black, the choke-damp of the miner. When this carbonic acid is made to traverse red hot charcoal it dissolves a portion of it, and becomes carbonic oxyde, which contains only one half of its volume of oxygen; whereas carbonic acid consists of one volume of oxygen combined with one volume of the vapor of carbon, the two being condensed into one volume. If the specific gravity of oxygen, $= 1.1025$, be deducted from that of carbonic acid, $= 1.5245$, the difference, $= 0.422$, will be the specific gravity of the vapor of carbon ; as well as the proportion present in that weight of the acid.

Charcoal obtained by the action of a rapid fire in close vessels is not so solid and so good a fuel as that which is made in the ancient way by the slow calcination of pyramidal piles covered with earth. One of the most economical ovens for making wood charcoal is that invented by M. Foucauld, which he calls a *shroud*, or *abri*. To construct one of these, 30 feet in diameter at the base, 10 feet at its summit, and from 8 to 9 feet high, he forms, with wood 2 inches square, a frame 12 feet long, 3 feet broad at one end, and one foot at the other. The figure will explain the construction. The uprights, A B and C D, of this frame are furnished with three wooden handles *a a a*, and *a′ a′ a′*, by means of which they can be joined together, by passing through two contiguous handles a wooden fork, the frame being previously provided with props, as shown in *fig.* 259, and covered with loam mixed with grass. A flat cover of 10 feet diameter, made of planks well joined, and secured by four cross bars, is mounted with two trap doors, M N, *fig.* 261, for giving egress to the smoke at the commencement of the operation; a triangular
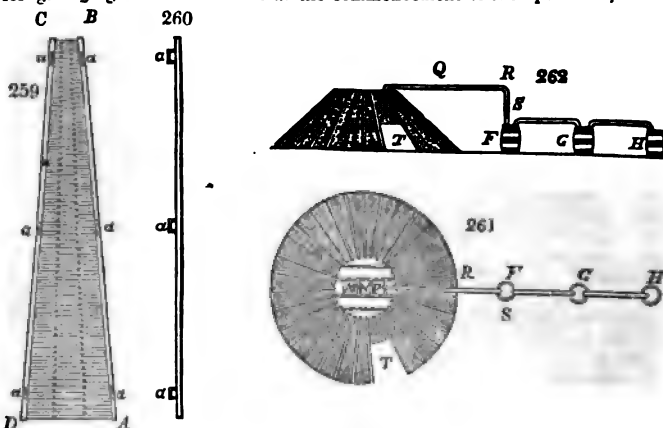
hole P, cut out in the cover, receives the end of a conduit Q R S, (*figs.* 262 and 261,) of wood formed of three deals, destined to convey the gases and condensed liquids into the casks F G H. Lastly, a door T, which may be opened and shut at pleasure, permits the operator to inspect the state of the fire. The charcoal calcined by this *abri*, has been found to be of superior quality.

When it is wished to change the place where the *abri* is erected, and to transport it to a store of new-felled timber, the frame is taken down, after beating off the clay which covers it, the joints are then cut by a saw, as well as the ends of the forks which fixed the frames to one another. This process is economical in use, simple and cheap in construction; since all the pieces of the apparatus are easily moved about, and may be readily mounted in the forests. For obtaining a compact charcoal, for the use of artisans, this mixed process of Foucauld is said to be preferable to either the close iron cylinder or the pile.

For making gunpowder-charcoal the lighter woods, such as the willow, dogwood, and alder answer best; and in their carbonization care should be taken to let the vapors freely escape, especially towards the end of the operation, for when they are re-absorbed, they greatly impair the combustibility of the charcoal.

By the common process of the forests, about 18 per cent. of the weight of the wood is obtained; by the process of Foucauld about 24 per cent. are obtained, with 20 of crude pyroligneous acid of 10 degrees Baumé. By the process described under ACETIC ACID, 27 of charcoal, and 18 of acid at 6 degrees, are procured from 100 parts of wood, besides the tar. These quantities were the results of careful experimenting, and are greater than can be reckoned upon in ordinary hands.

Charcoal for chemical purposes may be extemporaneously prepared by calcining pieces of wood covered with sand in a crucible, till no more volatile matter exhales.

The charcoal of some woods contains silica, and is therefore useful for polishing metals. Being a bad conductor of heat, charcoal is employed sometimes in powder to incase small furnaces and steam-pipes. It is not affected by water; and hence the extremities of stakes driven into moist ground are not liable to decomposition. In like manner casks when charred inside preserve water much better than common casks, because they furnish no soluble matter for fermentation or for food to animalcules.

Lowitz discovered that wood charcoal removes offensive smells from animal and vegetable substances, and counteracts their putrefaction. He found the odor of succinic

and benzoic acids, of bugs, of empyreumatic oils, of infusions of valerian, essence of wormwood, spirits distilled from bad grain, and sulphureous substances were all absorbable by freshly calcined charcoal properly applied. A very ingenious filter has been constructed for purifying water, by passing it through strata of charcoal of different fineness.

When charcoal is burned, one third of the heat is discharged by radiation, and two thirds by conduction.

The following table of the quantity of charcoal yielded by different woods was published by Mr. Mushet, as the result of experiments carefully made upon the small scale. He says, the woods before being charred were thoroughly dried, and pieces of each kind were selected as nearly alike in every respect as possible. One hundred parts of each sort were taken, and they produced as under:—

Lignum Vitæ afforded 26·0 of charcoal of a grayish color, resembling coke.
Mahogany - - - 25·4 tinged with brown, spongy and porous.
Laburnum - - 24·5 velvet black, compact, very hard.
Chestnut - - - 23·2 glossy black, compact, firm.
Oak - - - - 22·6 black, close, very firm.
Walnut - - - 20·6 dull black, close, firm.
Holly - - - 19·9 dull black, loose and bulky.
Beech - - - 19·9 dull black, spongy, firm.
Sycamore - - 19·7 fine black, bulky, moderately firm.
Elm - - - - 19·5 fine black, moderately firm.
Norway Pine - - 19·2 shining black, bulky, very soft.
Sallow - - - 18·4 velvet black, bulky, loose and soft.
Ash - - - - 17·9 shining black, spongy, firm.
Birch - - - 17·4 velvet black, bulky, firm.
Scottish Pine - - 16·4 tinged with brown, moderately firm.

Messrs. Allen and Pepys, from 100 parts of the following woods, obtained the quantities of charcoal as under:—

Beech	-	- 15·00	Oak	-	- 17·40
Mahogany	-	- 15·75	Fir -	-	- 18·17
Lignum Vitæ	-	- 17·25	Box	-	- 20·25

It is observable that the quantities obtained by Messrs. Allen and Pepys are in general less than those given by Mr. Mushet, which may be owing to Mr. Mushet not having applied sufficient heat, or operated long enough, to dissipate the aqueous matter of the gaseous products.

To those persons who buy charcoal by weight, it is important to purchase it as soon after it is made as possible, as it quickly absorbs a considerable portion of water from the atmosphere. Different woods, however, differ in this respect. Messrs. Allen and Pepys found, that by a week's exposure to the air, the charcoal of

Lignum Vitæ gained - 9·6 per cent.
Fir - - - - 13·0 ditto.
Box - - - - 14·0 ditto.
Beech - - - - 16·3 ditto.
Oak - - - - 16·5 ditto.
Mahogany - - - 18·0 ditto.

The following is a tabular view of the volumes of the different gases which were absorbed in the course of 24 hours, by one volume of charcoal, in the experiments of M. Theodore de Saussure, which were conducted in a way likely to produce correct results. Each portion of charcoal was heated afresh to a red heat, and allowed to cool under mercury. When taken from the mercury, it was instantly plunged into the vessel of gas:

Ammoniacal gas	-	- 90	Bicarbureted hydrogen	-	35·00
Muriatic acid gas	-	- 85	Carbonic oxyde	-	- 9·42
Sulphurous acid	-	- 65	Oxygen gas -	-	- 9·25
Sulphureted hydrogen	-	55	Nitrogen	-	- 7·50
Nitrous oxyde -	-	- 40	Carbureted hydrogen	-	5·00
Carbonic acid gas	-	- 35	Hydrogen gas	-	1·75

Neumann, who made many experiments on charcoal, informs us, that for the reduction of the metallic oxydes, the charcoal of the heavier woods, as that of the oak and the beech, is preferable, and that, for common fuel, such charcoal gives the greatest heat, and requires the most plentiful supply of air to keep it burning; while those of the lighter woods preserve a glowing heat with a much less draught of air; and that for purposes where it is desirable to have a steady and a still fire, charcoal should be employed which

has been made from wood previously divested of its bark, since it is the cortical part which crackles and flies off in sparks during combustion, while the coal of the wood itself seldom does.

For making crayons of charcoal, the willow is the best wood that can be employed, as the softness is uniform in all its parts. Its durability may be seen in several of our old churchyards, where the letters made with lamp-black are still perfect, though the white lead with which the body of the stones was painted is entirely destroyed.

This property of carbon is shown, however, in a more striking manner by the writings that were found in the ruins òf Herculaneum, which have retained their original blackness for two thousand years. The ancients wrote with ink made from ground charcoal.

If it be required to purify any carbonaceous matter, to render it fitter for delicate pigments, this may be done by first calcining it in a close vessel, and then lixiviating it in water slightly acidulated by nitric acid.

The incorruptibility of charcoal was well known to the ancients, and they availed themselves of this property upon all important occasions.

About sixty years ago a quantity of oak stakes were found in the bed of the Thames, in the very spot where Tacitus says that the Britons fixed a vast number of such stakes to prevent the passage of Julius Cæsar and his army. These stakes were charred to a considerable depth, had retained their form completely, and were firm at the heart.

Most of the houses in Venice stand upon piles of wood, which have all been previously charred for their preservation. In this country, estates were formerly marked out by charred stakes driven to a considerable depth into the ground. See BONE-BLACK, CHARCOAL, and GRAPHITE.

CARBONATED WATER is water either pure, or holding various saline matters in solution, impregnated with carbonic acid gas. For general sale in this country, the water usually contains a little soda, which being charged with the gas, is called *Soda water ;* see this article for a description of an excellent machine for the manufacture of this fashionable beverage.

CARBONATES. Saline compounds in definite proportions of carbonic acid, with alkalis, earths, and the ordinary metallic oxydes.

The carbonates principally used in the arts and manufactures are those of *ammonia, copper, iron, lead, lime, magnesia, potash, soda.* Native carbonate of copper is the beautiful green mineral called Malachite.

Carbonates are easily analyzed by estimating either by weight or measure the quantity of carbonic acid which they evolve under the decomposing action of somewhat dilute sulphuric, nitric, or muriatic acid ; for as they are all compounds of acid, and base in equivalent proportions, the quantity of acid will indicate the quantity of base. Thus, as pure limestone consists of 56 of lime and 44 of acid, in 100 parts, if upon examining a sample of limestone we find it to give out only 22 per cent. of carbonic acid gas, during its slow solution in muriatic acid, we are sure that there are only 28 parts of lime present. I have described, in the Annals of Philosophy for October, 1817, a simple form of apparatus for analyzing the carbonates with equal readiness and precision. The simple rule by *measure* to which I was led, may be thus stated : *From the bulk of evolved gas, expressed in cubic inches and tenths, deduct $\frac{1}{20}$, the remainder will express the proportion of real limestone present in the grains employed.* Pure magnesian limestone yields very nearly a cubic inch of the gas for every grain in weight.

CARBONATE OF AMMONIA. .A salt called in modern chemistry *sesqui-carbonate,* to denote its being composed of one and a half equivalent primes of carbonic acid, and one of ammonia. It consists by my analysis of 55·89 carbonic acid, 28·86 ammonia, and 15·25 water, in 100 parts. It is generally prepared by mixing from $1\frac{1}{4}$ to $1\frac{1}{2}$ parts of well-washed dry chalk, with 1 of sal-ammoniac, introducing the mixture into an earthen or cast-iron retort, or subliming pot, and exposing it to a heat gradually raised to redness. By double decomposition, the ammonia is volatilized in combination with the carbonic acid of the chalk, and the vapors are received in a condensing receiver made either of glass, stone ware, or lead. The chlorine of the sal-ammoniac remains in the retort, associated with the basis of the chalk in the state of chloride of calcium. Some ammonia gas escapes during the process.

The saline mass thus sublimed is purified by a second sublimation in glass or salt-glazed earthen vessels. The salt may be obtained, by the above method carefully conducted, in rhomboidal octahedrons, but it is generally made for the market in a compact semi-crystalline white cake. It has a pungent ammoniacal smell ; a hot, pungent, alkaline taste ; a strong alkaline reaction, and dissolves in two parts of cold water. It must be kept in well-closed vessels, as by exposure to the air a portion of its ammonia exhales, and it passes into the state of the scentless bi-carbonate. It is employed much in medicine, chemical analysis, and by the pastry-cooks to give sponginess to their cakes, in consequence of its volatilization from their dough in the oven. See SAL-AMMONIAC.

For the other carbonates used in the arts, see their respective bases ; copper, lead, lime, &c.

CARBONIC ACID (*Acide carbonique*, Fr.; *Kohlensaure*, Germ.) consists of 1 prime equivalent of carbon $=6\cdot125+2$ of oxygen $=16\cdot026$, whose joint sum $=22\cdot151$, represents the atomic weight or combining ratio of this acid, in the neutral or protocarbonate salts. Its composition by volume is stated under CARBON. Its natural form is a gas, whose specific gravity is $1\cdot5245$, compared to atmospheric air $1\cdot000$; and being so dense, it may be poured out of one vessel into another. Hence it was called at first *aërial acid*. From its existing copiously, in a solid state, in limestones and the mild alkalis, it was styled *fixed air* by its proper discoverer, Dr. Black. About one volume of it exists in 1000 volumes of common atmospheric air, which may be made manifest by the crust of carbonate it occasions upon the surface of lime water. Carbonic acid gas is found accumulated in many caverns of volcanic districts, and particularly in the *grotto dei cani* at Pausilippo, near Puzzuoli; being disengaged in such circumstances by the action of subterranean fire, and, possibly, of certain acids, upon the limestone strata. It often issues from fountains in copious currents, as at Franzensbrunn, near Eger, in Polterbrunnen; near Trier; and Byrreshorn. This acid gas occurs also frequently in mines and wells, being called *choke damp*, from its suffocating quality. Its presence may, at all times, be detected, by letting down a lighted candle, suspended from a string, into the places suspected of containing this mephitic air. It exists, in considerable quantities, in the water of every pump well, and gives it a fresh and pleasant taste. Water, exposed some time to the air, loses these aerial particles, and becomes vapid. Many springs are highly impregnated with carbonic acid gas, and form a sparkling beverage; such as the *Selterswasser*, from Selters upon the Lahn, in the grand dutchy of Nassau; of which no less than two millions and a half of bottles are sold every year. A prodigious quantity of a similar water is also artificially prepared in Great Britain, and many other countries, under the name of aërated or soda water.

Carbonic acid occurs in nature, combined with many salifiable bases; as in the carbonates of soda, baryta, strontia, magnesia; the oxydes of iron, manganese, zinc, copper, lead, &c. From these substances it may be separated, generally speaking, by strong ignition, or, more readily, by the superior affinity of muriatic, sulphuric, or nitric acid, for the earth or metallic oxyde. It is formed whenever vegetable or animal substances are burned with free access of air, from the union of their carbonaceous principle with atmospheric oxygen. It is also formed in all cases of the spontaneous decomposition of organic substances, particularly in the process of fermentation; and constitutes the pungent, noxious, heavy gas thrown off, in vast volumes, from beer vats. See DISTILLATION and FERMENTATION. Carbonic acid is also generated in the breathing of animals; from 4 to 5 per cent., in volume, of the inhaled oxygen being converted, at each expiration, into this gas, which contaminates the air of crowded apartments, and renders ventilation essential to health, and even to life; witness the horrible catastrophe of the Black-hole at Calcutta.

Carbonic acid gas is destitute of color, has a sourish, suffocating smell, an acidulous pungent taste, imparts to moist, but not dry, litmus paper, a transient reddish tint, and weighs per 100 cubic inches, $46\frac{1}{4}$ grains; and per cubic foot, $803\frac{1}{2}$ grains; a little more than $3\frac{3}{4}$ oz. avoirdupoise. A cubic foot of air weighs about two thirds of that quantity, or 527 grains. It may be condensed into the liquid state by a pressure of 40 atmospheres, and this liquid may be then solidified by its own sudden spontaneous evaporation. If air contain more than 15 per cent. in bulk of this gas, it becomes unfit for respiration and combustion, animal life and candles being speedily extinguished by it.

Before a person ventures into a deep well, or vault containing fermenting materials, he should introduce a lighted candle into the space, and observe how it burns. Carbonic acid, being so much denser than common air, may be drawn out of cellars or fermenting tubs, by a pump furnished with a leather hose, which reaches to the bottom. Quicklime, mixed with water, may be used also to purify the air of a sunk apartment, by its affinity for, or power of, absorbing this aerial acid. See MINERAL WATERS and SODA WATER.

CARBONIC OXYDE. See the article CARBON.

CARBUNCLE. A gem highly prized by the ancients; most probably a variety of the noble garnet of modern mineralogists.

CARBURET OF SULPHUR, called also sulphuret of carbon, and alcohol of sulphur, is a limpid volatile liquid possessing a penetrating fetid smell, and an acrid burning taste. Its specific gravity is $1\cdot265$; and its boiling point is about 112° Fahr. It evaporates so readily, and absorbs so much heat in the vaporous state, that if a tube containing quicksilver, surrounded with lint dipped in this liquid, be suspended in the receiver of an air-pump on making the vacuum, the quicksilver will be congealed. It consists of $15\cdot8$ carbon and $84\cdot2$ sulphur, in 100 parts; being two equivalent primes of the latter to one of the former.

CARBURETED HYDROGEN. A compound of carbon and hydrogen, of which there are several species—such as oil-gas, coal-gas, olefiant gas, oil of lemons, otto of roses, oil of turpentine, petroleum, naptha, napthaline, oil of wine, caoutchoucine, and caoutchouc.

CARDS, PLAYING. (*Cartes à jouer*, Fr.; *Karten*, Germ.) Mr. de la Rue obtained, in February, 1832, a patent for certain improvements in the manufacture of playing cards, which he distributed under three heads; first, printing the pips, and also the picture or court cards, in oil colors by means of types or blocks; secondly, effecting the same in oil colors by means of lithography; and thirdly, gilding or silvering borders, and other parts of the characters, by the printing process, either by types, blocks, or lithography.

In the ordinary mode of manufacturing playing cards, their devices are partly produced by copperplate printing, and they are filled up with water colors by the means called stencilling.

The patentee does not propose any material alteration in the devices or forms upon the cards, but only to produce them with oil colors; and, to effect this, he follows precisely the same mode as that practised by calico printers.

A set of blocks or types properly devised, are produced for printing the different pips of hearts, diamonds, spades, and clubs, or they are drawn, as other subjects, in the usual way upon stone. The ink or color, whether black or red, is to be prepared from the best French lamp-black, or the best Chinese vermilion ground in oil, and laid on the types and blocks, or on the stone, in the same way as printers' ink, and the impressions taken-on to thick drawing paper by means of a suitable press in the ordinary manner of printing.

The picture or court-cards are to be produced by a series of impressions in different colors, fitting into each other exactly in the same way as in printing paper hangings, or silks and calicoes, observing that all the colors are to be prepared with oil.

For this purpose a series of blocks or types are to be provided for each subject, and which, when put together, will form the whole device. These blocks are to be used separately, that is, all the yellow parts of the picture, for instance, are to be printed at one impression, then all the red parts, next all the flesh color, then the blue portions, and so on, finishing with the black outlines, which complete the picture.

If the same is to be done by lithography, there must be as many stones as there are to be colors, each to print its portion only; and the impression, or part of the picture given by one stone, must be exactly fitted into by the impression given from the next stone, and so on until the whole subject is complete.

A superior kind of card is proposed to be made, with gold or silver devices in parts of the pictures, or gold or silver borders round the pips. This is to be effected by printing the lines which are to appear as gold or silver, with gilders' size, in place of ink or color; and immediately after the impression has been given, the face of the card is to be powdered over with gold dust, silver, or bronze, by means of a soft cotton or wool dabber, by which the gold, silver, or bronze will be made to adhere to the picture, and the superfluous portions of the metal will wipe off by a very slight rubbing. When the prints are perfectly dry, the face of the card may be polished by means of a soft brush.

If it should be desirable to make these improved cards to resemble ivory, that may be done by preparing the face of the paper in the first instance with a composition of size and fine French white, and a drying oil, mixed together to about the consistency of cream; this is to be washed over the paper, and dried before printing, and when the cards are finished they will exactly resemble ivory.

The only thing remaining to be described, is the means by which the successive impressions of the types, blocks, or stones, forming the parts of the pictures, are to be brought exactly to join each other, so as to form a perfect whole design when complete; this is by printers called registering, and is to be effected much in the usual way, by points in the tympan of the press, or by marks upon the stones.

The parts of the subject having been all accurately cut or drawn to fit, small holes are to be made with a fine awl through a quire or more of the paper at once, by placing upon the paper a gauge-plate, having marks or guide-holes, and by observing these, the same sheet laid on several times, and always made to correspond with the points or marks, the several parts of the picture must inevitably register, and produce a perfect subject.

CARD CUTTING. Mr. Dickinson's patent machine for cutting cards, consists of a pair of rollers with circular revolving cutters, the edges of which are intended to act against each other as circular shears, and the pasteboards in passing between these rollers are cut by the circular shears into cards of the desired dimensions. These rollers are mounted in suitable standards, with proper adjustments, and are made to revolve by

a band and pulley connected to the axle of a crank, or by any other convenient means.
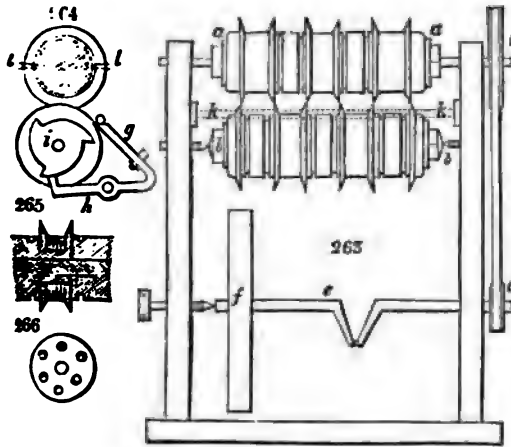
Fig. 263 is a front view of this machine; *a a* and *b b* are the two rollers, the upper one turning upon an extended axle, bearing in the standards, the lower one upon pivots. These rollers are formed by a series of circular blocks, between a series of circular steel cutters, which are slidden on to iron shafts, and held together upon their axle by nuts screwed up at their ends. The accurate adjustment of the cutters is of the first importance to their correct performance; it is therefore found necessary to introduce spiral springs within the blocks, in order to press the cutters up to their proper bearings. A section of one of the blocks is shown at *fig.* 265, and an end view of the same at *fig.* 266, with the spiral springs inserted.

At the outer extremity of the axle of the roller *a*, a rigger *c*, is attached, whence a band passes to a pulley *d*, on the crank shaft *e*, to which a fly-wheel *f*, is affixed, for the purpose of rendering the action uniform. Rotatory motion being given to the crank shaft, the upper roller is turned, the lower roller moving at the same time by the friction against the edges of the cutters.

Fig. 264 is an end view of the rollers, showing the manner in which the pasteboards are guided and conducted between the cutters. In the front of the machine a moveable frame *g*, is to be placed, for the purpose of receiving the pasteboards, preparatory to cutting them into cards, and a stop is screwed to this frame for the edge of the pasteboard to bear against, which stop is adjustable to suit different sizes. From the back part of this frame an arm *h*, extends, the extremity of which acts against the periphery of a ratchet wheel *i*, fixed at the end of the roller *b*, and hence, as the roller goes round, the frame is made to rise and fall upon its pivots, for the purpose of guiding the pasteboard up to the cutters; at the same time a rod *k*, hanging in arms from the sides of the standards (shown by dots in *fig.* 263), falling upon the pasteboard, confines it, while the cutters take hold, and racks corresponding with the indentations of the rollers are placed as at *l l*, by means of which the cards, when cut, are pushed out of the grooves.

As various widths of cards will require to be cut by this machine, the patentee proposes to have several pairs of rollers ready adjusted to act together, when mounted in the standards, in preference to shifting the circular cutters, and introducing blocks of greater or less width.

The second part of the invention is a machine for pasting the papers, and pressing the sheets together to make pasteboard. This machine consists of several reels (we suppose rollers are intended) on which the paper is to be wound, along with a paste trough, and rotatory brushes. The several parts of this machine, and their operations in making pasteboard, are described in the specification, but the patentee having omitted the letters of reference in the drawing which he has enrolled, it becomes difficult to explain it.

As far as we are enabled to understand the machine, it appears, that damped paper is to be wound upon two rollers, and conducted from thence over two other rollers; that two fluted rollers revolving in the paste trough are to supply paste to two circular brushes, and that by those brushes the papers are to be pasted upon one side, and then pressed together, to make the pasteboard; after this, the pasteboard is to be drawn on to a table, and to remain there until sufficiently dry to be wound upon other rollers. By comparing this description with the figure, perhaps the intended operations of the machine may be discovered: it is the best explanation we are enabled to give.

CARDS (*Cardes*, Fr.; *Karden*, Germ.) are instruments which serve to disentangle the fibres of wool, cotton, or other analogous bodies, to arrange them in an orderly lap or fleece, and thereby prepare them for being spun into uniform threads. The fineness and the levelness of the yarn, as well as the beauty of the cloth into which it enters,

depend as much upon the regularity and perfection of the carding, as upon any subsequent operations of the factory. The quality of the carding depends more upon that of the cards than upon any attention or skill in the operative; since it is now nearly an automatic process, conducted by young women called card-tenters.

Cards are formed of a sheet or fillet of leather pierced with a multitude of small holes, in which are implanted small staples of wire with bent projecting ends called *teeth*. Thus every piece of wire is double toothed. The leather is afterwards applied to a flat or cylindrical surface of wood or metal, and the co-operation of two or more such surfaces constitutes a card. The teeth of cards are made thicker or slenderer, according as the filaments to be carded are coarser or finer, stiffer or more pliant, more valuable or cheaper. It is obviously of great importance that the teeth should be all alike, equally distributed, and equally inclined over the surface of the leather, a degree of precision which is scarcely possible with handwork. To judge of the difficulty of this manipulation we need only inspect the annexed figures. The wire must first be bent at right angles in c and d, *fig.* 268, then each branch must receive a second bend in *a* and *b* at a determinate obtuse angle, invariable for each system of cards. It is indispensable that the two angles *c a e* and *d b f* be mathematically equal, not only as to the twin teeth of one staple, but through the whole series; for it is easy to see that if one of the teeth be more or less sloped than its fellow, it will lay hold of more or less wool than it, and render the carding irregular. But though the perfect regularity of the teeth be important, it is not the sole condition towards making a good card. It must be always kept in view that these teeth are to be implanted by pairs in a piece of leather, and kept in it by the cross part *c d*. The leather must therefore be pierced with twin holes at the distance *c d*; and pierced in such a manner, that the slope of the holes, in reference to the plane of the leather, be invariably the same; for otherwise the length of the teeth would vary with this angle of inclination, and the card would be irregular.

A third condition essential towards producing perfect regularity, is that the leather ought to be of the same thickness throughout its whole surface, otherwise the teeth, though of the same length and fixed at the same angle, would be rendered unequal by the different thicknesses of the leather, and the operation of carding would be in consequence

extremely defective. *Fig.* 267 shows the card teeth acting against each other, as indicated by the arrows in two opposite directions; in *fig.* 269 they work one way.

Of late years very complex but complete and well-acting machines have been constructed for splitting the leather or equalizing it by shaving, for bending and cutting the wires, and implanting them in the leather, into holes pierced with perfect regularity. Card machines which fashion the teeth with great precision and rapidity, and pierce the leather, have been for a considerable time in use at Halifax, in Yorkshire, a town famous for the excellence of its card-cloth, as also at Leeds, Glasgow, and several other places. The wires and the leather thus prepared are given out by the manufacturer to women and children, who put them together.

1. The simplest machine for equalizing the leather which can be employed, is that which I saw operating in MM. Scrive's automatic card factory at Lille, the most magnificent I believe in the world, where the leather was drawn forwards by a roller over a solid horizontal table, or bed, and passed under a nicely adjusted vertical blade, which shaved it by a scraping motion to a perfectly uniform thickness. About one half the weight of the leather is lost in this process, and in the subsequent squaring and trimming.

The machine for making cards, invented I believe by a Mr. Ellis of the United States, for which a first patent was obtained in this country by Joseph Cheeseborough Dyer, Esq. of Manchester, in 1811, and a second and third with further improvements in 1814, and 1824, is one of the most elegant automatons ever applied to productive industry. It is, however, necessarily so complicated with different mechanisms as to render its representation impracticable in such engravings as are compatible with the scope of this dictionary. I must therefore content myself with the following general description of its constituent parts.

The first thing to be done after having, as above, prepared the long sheets or fillets of leather of suitable length, breadth, and thickness, for making the cards, is to stretch the leather, and hold it firmly; which is accomplished by winding the fillet of leather upon the roller or drum, like the warp roller of a loom, and then conducting it upwards between guide rollers, to a receiving or work roller at top of the machine, where the fillet is held fast by a cramp, by which means the leather is kept stretched.

Secondly, the holes are pierced in the leather to receive the wire staples or teeth of the

card, by means of a sliding fork, the points of which are presented to the face of the leather; while the fork is made to advance and recede continually, by the agency of levers worked by rotatory cams upon a revolving main shaft.

The points of the fork being thus made to penetrate into the leather, the holes for receiving the staples are pierced at regular distances, and in correct order, by shifting the leather fillet so as to bring different parts of its surface opposite to the points of the sliding fork. This is done by cams, or indented wheels and gear, which shift the guide rollers and confining drums laterally, as they revolve, and consequently move the fillet of leather at intervals a short distance, so as to present to the points of the fork or piercer, at every movement, a different part of the surface of the leather.

Thirdly, the wire of which the teeth or points of the card are to be made, is supplied from a coil on the side of the machine, and is brought forward at intervals by a pair of sliding pincers, which are slidden to and fro through the agency of levers actuated by rotatory cams upon the main shaft. The pincers having advanced a distance equal to the length of wire intended to form one staple or two points, this length of wire is pressed upon exactly in the middle by a square piece of steel, and being there confined, a cutter is brought forward, which cuts it off from that part of the wire held in the pincers.

The length of wire thus separated and confined is now, by a movement of the machine, bent up along the sides of the square steel holder, and shaped to three edges of the square, that is, formed as a staple; and in the same way, by the continued movements of the machine, a succession of pieces of wire are cut off, and bent into staples for making the teeth of the card as long as the mechanism is kept in action.

Fourthly, the wire staple thus formed is held with its points or ends outwards, closely contiguous to the forked piercer described above, and by another movement of the mechanism, the staple is protruded forward, its end entering into the two holes made previously in the leather by the sliding of the fork.

While the wire staple is being thus introduced into the leather, its legs or points are to be bent, that is, formed with a knee or angle, which is the fifth object to be effected. This is done by means of a small apparatus consisting of a bar or bed, which bears up against the under side of the wire staple when it has been passed half way into the holes in the leather, and another bar above it, which, being brought down behind the staple, bends it over the resisting bar to the angle required; that is, forms the knee in each leg. A pusher now acts behind the staple, and drives it home into the leather, which completes the operation.

The leather being thus conducted, and its position shifted before the piercer progressively, a succession of the above described operations of cutting the wire, forming the staple, passing it into the leather, and bending its legs to the angular form, produces a sheet of card of the kind usually employed for carding or combing wool, cotton, and other fibrous materials. It may be necessary to add, that as these wire staples are required to be set in the leathers sometimes in lines crossing the sheet, which is called ribbed, and at other times in oblique lines, called twilled, these variations are produced by the positions of the notches or steps upon the edge or periphery of the cam or indented wheel, which shifts the guide rollers that hold the fillet or sheet of leather as already described.

CARMINE (Eng. and Fr.; *Karminstoff*, Germ.) is, according to Pelletier and Caventou, a triple compound of the coloring substance, and an animal matter contained in cochineal, combined with an acid added to effect the precipitation. The preparation of this article is still a mystery, because, upon the one hand, its consumption being very limited, few persons are engaged in its manufacture, and upon the other, the raw material being costly, extensive experiments on it cannot be conveniently made. Success in this business is said to depend not a little upon dexterity of manipulation, and upon knowing the instant for arresting the further action of heat upon the materials.

There is sold at the shops different kinds of carmine, distinguished by numbers, and possessed of a corresponding value. This difference depends upon two causes; either upon the proportion of alumina added in the precipitation, or of a certain quantity of vermilion put in to dilute the color. In the first case the shade is paler, in the second it has not the same lustre. It is always easy to discover the proportion of the adulteration. By availing ourselves of the property of pure carmine to dissolve in water of ammonia, the whole foreign matter remains untouched, and we may estimate its amount by drying the residuum.

To make Ordinary Carmine.

Take 1 pound of cochineal in powder;
  3 drachms and a half of carbonate of potash;
  8 drachms of alum in powder;
  3 drachms and a half of fish-glue.

The cochineal must be boiled along with the potash in a copper containing five pailsful of water (60 pints); the ebullition being allayed with cold water. After boiling a

few minutes the copper must be taken from the fire, and placed on a table at such an angle as that the liquor may be conveniently transvased. The pounded alum is then thrown in, and the decoction is stirred; it changes color immediately, and inclines to a more brilliant tint. At the end of fifteen minutes the cochineal is deposited at the bottom, and the bath becomes as clear as if it had been filtered. It contains the coloring matter, and probably a little alum in suspension. We decant it then into a copper of equal capacity, and place it over the fire, adding the fish-glue dissolved in a great deal of water, and passed through a searce. At the moment of ebullition, the carmine is perceived to rise up to the surface of the bath, and a coagulum is formed, like what takes place in clarifications with white of egg. The copper must be immediately taken from the fire, and its contents be stirred with a spatula. In the course of fifteen or twenty minutes the carmine is deposited. The supernatant liquor is decanted, and the deposite must be drained upon a filter of fine canvass or linen. If the operation has been well conducted, the carmine, when dry, crushes readily under the fingers. What remains after the precipitation of the carmine is still much loaded with color, and may be employed very advantageously for carminated lakes. See LAKE.

By the *old German process*, carmine is prepared by means of alum without any other addition. As soon as the water boils, the powdered cochineal is thrown into it, stirred well, and then boiled for six minutes; a little ground alum is added, and the boiling is continued for three minutes more; the vessel is removed from the fire, the liquor is filtered and left for three days in porcelain vessels, in the course of which time a red matter falls down, which must be separated and dried in the shade. This is carmine, which is sometimes previously purified by washing. The liquor after three days more lets fall an inferior kind of carmine, but the residuary coloring matter may also be separated by the muriate of tin.

The proportions for the above process are 580 parts of clear river water, 16 parts of cochineal, and 1 part of alum; there is obtained from 1½ to 2 parts of carmine.

Another *carmine with tartar.*—To the boiling water the cochineal is added, and after some time a little cream of tartar; in eight minutes more we add a little alum, and continue the boiling for a minute or two longer. Then take it from the fire and pour it into glass or porcelain vessels, filter, and let it repose quietly till the carmine falls down. We then decant and dry in the shade. The proportions are 8 pounds of water, 8 oz. of cochineal, ½ oz. of cream of tartar, ⅛ oz. of alum, and the product is an ounce of carmine.

The process of Alxon or Langlois.—Boil two pails and a half of river water (30 pints), throw into it, a little afterwards, a pound of cochineal, add a filtered solution of six drachms of carbonate of soda and a pound of water, and let the mixture boil for half an hour; remove the copper from the fire, and let it cool, inclining it to one side. Add six drachms of pulverized alum, stir with a brush to quicken the solution of the salt, and let the whole rest 20 minutes. The liquor, which has a fine scarlet color, is to be carefully decanted into another vessel, and there is to be put into it the whites of two eggs well beat up with half a pound of water. Stir again with a brush. The copper is replaced on the fire, the alumina becomes concrete, and carries down the coloring matter with it. The copper is to be taken from the fire, and left at rest for 25 or 30 minutes to allow the carmine to fall down. When the supernatant liquor is drawn off, the deposite is placed upon filter cloth stretched upon a frame to drain. When the carmine has the consistence of cream cheese, it is taken from the filter with a silver or ivory knife and set to dry upon plates covered with paper, to screen it from dust. A pound of cochineal gives in this way an ounce and a half of carmine.

Process of Madame Cenette, of Amsterdam, with salt of sorrel.—Into six pails of river water boiling hot throw two pounds of the finest cochineal in powder, continue the ebullition for two hours, and then add 3 oz. of refined saltpetre, and after a few minutes 4 oz. of salt of sorrel. In ten minutes more take the copper from the fire and let it settle for four hours; then draw off the liquor with a syphon into flat plates and leave it there for three weeks. Afterwards there is formed upon the surface a pretty thick mouldiness, which is to be removed dexterously in one pellicle by a slip of whalebone. Should the film tear and fragments of it fall down, they must be removed with the utmost care. Decant the supernatant water with a syphon, the end of which may touch the bottom of the vessel, because the layer of carmine is very firm. Whatever water remains must be sucked away by a pipette. The carmine is dried in the shade, and has an extraordinary lustre.

Carmine by the salt of tin, or the Carmine of China.—Boil the cochineal in river water, adding some Roman alum, then pass through a fine cloth to remove the cochineal, and set the liquor aside. It becomes brighter on keeping. After having heated this liquor, pour into it, drop by drop, solution of tin till the carmine be precipitated. The proportions are one pailful of water, 20 oz. of cochineal, and 60 grains of alum, with a solution of tin containing 4 oz. of the metal.

To revive or brighten carmine.—We may brighten ordinary carmine, and obtain a very fine and clear pigment, by dissolving it in water of ammonia. For this purpose we leave ammonia upon carmine in the heat of the sun, till all its color be extracted, and the liquor has got a fine red tinge. It must be then drawn off and precipitated, by acetic acid and alcohol, next washed with alcohol, and dried. Carmine dissolved in ammonia has been long employed by painters, under the name of liquid carmine.

Carmine is the finest red color which the painter possesses. It is principally employed in miniature painting, water colors, and to tint artificial flowers, because it is more transparent than the other colors. For *Carminium*, see COCHINEAL.

CARPET. (*Tapis*, Fr.; *Teppich*, Germ.) A thick woollen fabric of variegated colors, for covering the floors of the better sort of apartments. This luxurious manufacture took its origin in Persia and Turkey, whence the most beautiful patterns were wont to come into Europe; but they have been for some time surpassed by the workmanship of France, Great Britain, and Belgium. To form a just conception of the elegant and ingenious processes by which carpets are made, we should visit the royal establishment of the Gobelins at Paris, where we would see the celebrated carpet manufactory of the Savonnerie, which has been transported thither. A detailed set of engravings of this art is given by Roland de la Platière in the first and second volumes of the Encyclopédie Méthodique, to which I must refer my readers, as a due exposition of its machines and operations would far exceed the scope of the present volume.

The warp, says M. Roland, being the foundation of the fabric, ought to be of fine wool, equally but firmly spun, and consist of three yarns twisted into one thread. The yarns that are to form the velvety surface of the carpet, ought also to be of the best quality, but soft and downy in their texture, so that the dye may penetrate every filament. Hemp, or linen yarns, are likewise employed in this manufacture, as a woof, to bind the warp firmly together after each shoot of the velvety threads. Thus we see that good carpeting consists essentially of two distinct webs woven at the same time, and firmly decussated together by the woof threads. Hence the form of the pattern is the same upon the two sides of the cloth, only the colors are reversed, so that what was green upon one side becomes red or black upon the other, and *vice versa*. The smaller the figures the more frequent the decussations of the two planes, and the firmer and more durable the fabric.

The carpet manufacture, as now generally practised, may be distributed into two systems—that of double fabrics, and that cut in imitation of velvet. Of late years the Jacquard loom has been much used in weaving carpets, the nature of which will be found fully explained under that title.

For the sake of illustration, if we suppose the double carpets to be composed of only two colors, the principle of weaving will be easily understood; for it is only necessary to raise the warp of each web alternately for the passage of the shuttle, the upper web being entirely above when the under web is being woven, or decussated, and *vice versa*. In a Brussels carpet the worsted yarn raised to form the pile, and make the figure, is not cut; in the Wilton the pile is cut to give it a velvety aspect and softness. In the imperial Brussels carpet the figure is raised above the ground, and its pile is cut, but the ground is uncut; and in the royal Wilton, the pile is both raised higher than in the common Wilton, and it is cut, whereby it has a rich cushion-like appearance. The cloth of all these superior carpets consists of woollen and linen, or hemp; the latter being put upon a beam, and brought, of course, through heddles and a reed; but as its only purpose is to bind together the worsted fabric, it should not be visible upon the upper face of the carpet. The worsted yarn is wound upon small bobbins or pirns, with a weight affixed to each, for giving proper tension to the threads. Their number varies, for one web, from 1300 to 1800, according as the carpet is to be 27 or 36 inches wide; and they are placed, in frames, behind the loom, filled with differently colored yarn, to correspond with the figure. This worsted warp is then drawn through the harness, heddles, and reed, to be associated with the linen yarn in the compound fabric.

In Kidderminster carpeting, both warp and weft appear upon the face of the cloth, whereas, in the Brussels style, only the warp is seen, its binding weft being fine hempen or linen threads. The three-ply imperial carpet, called the Scotch, is coming very much into vogue, and is reckoned by many to be little inferior in texture, look, and wear to the Brussels. Kilmarnock has acquired merited distinction by this ingenious industry. In this fabric, as well as in the two-ply Kidderminster, the weft predominates, and displays the design; but in the French carpets, the worsted warp of the web shows the figure. Plain Venetian carpets, as used for stairs and passages, are woven in simple looms, provided merely with the common heddles and reed. The warp should be a substance of worsted yarn, so heavy as to cover in the weft completely from the view. Figured Venetian carpets are woven in the two-ply Kidderminster looms, and are

provided with a mechanism to raise the pattern upon the worsted warp. The weft is an alternate shoot of worsted and linen yarn, and must be concealed.

The following figure and description will explain the construction of the three-ply imperial Scotch and two-ply Kidderminster carpet-loom, which is merely a modification of the Jacquard *métier*. The Brussels carpet-loom, on the contrary, is a draw-Loy loom

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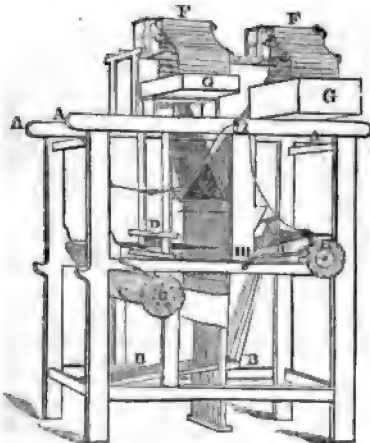
on the damask plan, and requires the weaver to have an assistant. *Fig.* 270, A A A, is the frame of the loom, consisting of four upright posts, with caps and cross rails to bind them together. The posts are about six feet high. c c, the cloth-beam, is a wooden cylinder, six inches or thereby in diameter, of sufficient length to traverse the loom, with iron gudgeons in the two ends, which work in bushes in the side frame. On one end of this beam is a ratchet wheel, with a tooth to keep it from turning round backwards by the tension of the web. D, the lay, with its reed, its under and upper shell, its two lateral rulers or swords, and rocking-tree above. There are grooves in the upper and under shell, into which the reed is fitted. E, the heddles, or harness, with a double neck attached to each of the tower or card mechanisms F F, of the Jacquard loom. The heddles are connected and work with

the treddles B B, by means of cords, as shown in the figure. G G are wooden boxes for the cards. H, the yarn or warp-beam.

In draw-looms of every kind, there is no sinking of any portion of the warp, as in plain cloth-weaving; but the plane of the warp is placed low, and the threads under which the shuttle is to pass are raised, while all the rest remains stationary. The harness part of this carpet-loom is moved by an assistant boy or girl, who thus allows the weft to be properly decussated, while the weaver attends to working the front

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mounting or heddles. *Fig.* 271, A represents the frame of a carpet draw-loom; B is a box or frame of pulleys, over which the cords of the harness pass, and are then made fast to a piece of wood, seen at E, which the weavers call a table. From the tail of the harness the simples descend, and to the end of each is attached a small handle G, called a bob. These handles being disposed in pairs, and their regularity preserved by means of a perforated board c, it is merely necessary to pull every handle in succession; the weaver, at the same time, working his treddles with his feet, as in any other loom. The treddles are four
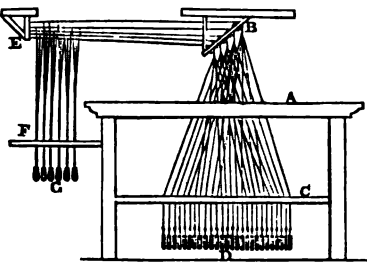
in number, the fabric being that of plain or alternate cloth, and two treddles allotted for each web. The harness part of the carpet draw-loom is furnished with *mails*, or metallic eyes, to save friction; two threads being drawn through each eye. The design or pattern of a carpet is drawn upon cross-rule paper, exactly in the same way as every other kind of fancy-loom work, and is transferred from the paper to the mounting by the rules for damask weaving. Suppose that a double web is so mounted that every alternate thread of the one may be raised, so as to form a sufficient shed-way for the shuttle, without depressing the other in the least. Then suppose another web placed above the former, at such a distance that it will exactly touch the convexity of those threads of the former which are raised. Then, if the threads of the latter web are sunk while the others are raised, the two would be entirely incorporated. But if this be only partially done, that is, at particular places, only those parts immediately operated upon will be affected by the action of the apparatus. If the carpet is a two-colored pattern, as black and red, and if upon the upper surface, as extended in the loom, red flowers are to be represented upon a black ground, then all those species of design paper which are colored may be supposed to represent

the red, and those which are vacant the black. Then counting the spaces upon the paper, omit those which are vacant, and cord those which are colored, and the effect will be produced. But as the two webs are to be raised alternately, whatever is corded for the first handle must be passed by for the second, and *vice versa ;* so that the one will form the flower, and the other the ground.

The board by which the simples are regulated appears at F. D shows the weights.

CARTHAMUS, or safflower (carthamus tinctorius), (*Carthame,* Fr.; *F rber distel,* Germ.), the flower of which alone is used in dyeing, is an annual plant cultivated in Spain, Egypt, and the Levant. There are two varieties of it — one which has large leaves, and the other smaller ones. It is the last which is cultivated in Egypt, where it forms a considerable article of commerce.

Carthamus contains two coloring matters, one yellow and the other red. The first alone is soluble in water; its solution is always turbid: with re-agents it exhibits the characters usually remarked in yellow coloring matters. The acids render it lighter, the alkalis deepen it, giving it more of an orange hue: both produce a small dun precipitate, in consequence of which it becomes clearer. Alum forms a precipitate of a deep yellow, in small quantity. The solution of tin and the other metallic solutions cause precipitates which have nothing remarkable in them.

The yellow matter of carthamus is not employed; but in order to extract this portion, the carthamus is put into a bag, which is trodden under water, till no more color can be pressed out. The flowers, which were yellow, become reddish, and lose in this operation nearly one half of their weight. In this state they are used.

For extracting the red part of carthamus, and thereafter applying it to stuff, the property which alkalis possess of dissolving it is had recourse to, and it is afterwards precipitated by an acid.

The process of dyeing consists, therefore, in extracting the coloring matter by means of an alkali, and precipitating it on the stuff by means of an acid. It is this fecula which serves for making the rouge employed by ladies.

As to this rouge, the solution of carthamus is prepared with crystallized carbonate of soda, and it is precipitated by lemon juice. It has been remarked that lemons, beginning to spoil, were fitter for this operation than those which were less ripe, whose juice retained much mucilage. After squeezing out the lemon juice, it is left to settle for some days. The precipitate of carthamus is dried at a gentle heat upon plates of stone-ware; from which it is detached and very carefully ground with talc, which has been reduced to a very subtile powder, by means of the leaves of shave-grass (*presle*), and successively passed through sieves of increasing fineness. It is the fineness of the talc, and the greater or less proportion which it bears to the carthamus precipitate, which constitute the difference between the high and low priced rouges.

Carthamus is used for dyeing silk, poppy, *nacarat* (a bright orange-red), cherry, rose color, and flesh color. The process differs according to the intensity of the color, and the greater or less tendency to flame color that is wanted. But the carthamus bath, whose application may be varied, is prepared as follows:

The carthamus, from which the yellow matter has been extracted, and whose lumps have been broken down, is put into a trough. It is repeatedly sprinkled with cendres gravelees (crude pearlashes), or soda (barilla) well powdered and sifted at the rate of 6 pounds for 120 lbs. of carthamus; but soda is preferred, mixing carefully as the alkali is introduced. This operation is called *amestrer.* The *amestred* carthamus is put into a small trough with a grated bottom, first lining this trough with a closely woven cloth. When it is about half filled, it is placed over the large trough, and cold water is poured into the upper one, till the lower becomes full. The carthamus is then set over another trough, till the water comes from it almost colorless. A little more alkali is now mixed with it, and fresh water is passed through it. These operations are repeated till the carthamus be exhausted, when it turns yellow.

After distributing the silk in hanks upon the rods, lemon juice, brought in casks from Provence, is poured into the bath till it becomes of a fine cherry color; this is called turning the bath (*virer le bain*). It is well stirred, and the silk is immersed and turned round the skein-sticks in the bath, as long as it is perceived to take up the color. For *ponceau* (poppy color), it is withdrawn, the liquor is run out of it upon the peg, and it is turned through a new bath, where it is treated as in the first. After this it is dried and passed through fresh baths, continuing to wash and dry it between each operation, till it has acquired the depth of color that is desired. When it has reached the proper point, a brightening is given it by turning it round the sticks seven or eight times in a bath of hot water, to which about half a pint of lemon juice for each pailful of water has been added.

When silk is to be dyed *ponceau* or flame color, it must be previously boiled as for white; it must then receive a slight foundation of annotto, as explained in treating of this substance. The silk should not be alumed.

The *nacarats*, and the deep cherry colors, are given precisely like the *ponceaux*, only they receive no annotto ground; and baths may be employed which have served for the *ponceau*, so as to complete their exhaustion. Fresh baths are not made for the latter colors, unless there be no occasion for the poppy.

With regard to the lighter cherry-reds, rose color of all shades and flesh colors, they are made with the second and last runnings of the carthamus, which are weaker. The deepest shades are passed through first.

The lightest of all these shades, which is an extremely delicate flesh color, requires a little soap to be put into the bath. This soap lightens the color, and prevents it from taking too speedily, and becoming uneven. The silk is then washed, and a little brightening is given it, in a bath which has served for the deeper colors

All these baths are employed the moment they are made, or as speedily as possible, because they lose much of their color upon keeping, by which they are even entirely destroyed at the end of a certain time. They are, moreover, used cold, to prevent the color from being injured. It must have been remarked in the experiments just described, that the caustic alkalis attack the extremely delicate color of carthamus, making it pass to yellow. This is the reason why crystals of soda are preferred to the other alkaline matters.

In order to diminish the expense of the carthamus, it is the practice in preparing the deeper shades to mingle with the first and the second bath about one fifth of the bath of archil.

Dobereiner regards the red coloring matter of carthamus as an acid, and the yellow as a base. His carthamic acid forms, with the alkalis, colorless salts, decomposed by the tartaric and acetic acids, which precipitate the acid of a bright rose-red. Heat has a remarkable influence upon carthamus, rendering its red color yellow and dull. Hence, the colder the water is by which it is extracted, the finer is the color. Light destroys the color very rapidly, and hitherto no means have been found of counteracting this effect. For this reason this brilliant color must be dried in the shade, its dye must be given in a shady place, and the silk stuffs dyed with it must be preserved as much as possible from the light. Age is nearly as injurious as light, especially upon the dye in a damp state. The color is very dear, because a thousand parts of carthamus contain only five of it.

In preparing the finest rouge, the yellow coloring matter being separated by washing with water, the red is then dissolved by the aid of alkali, and is thrown down on linen or cotton rags by saturating the solution with vegetable acid. The color is rinsed out of these rags, dissolved anew in alkalis, and once more precipitated by lemon juice. The best and freshest carthamus must be selected. It is put into linen bags, which are placed in a stream of water, and kneaded till the water runs off colorless. The bags are then put into water soured with a little vinegar, kneaded till the color is all expelled, and finally rinsed in running water. By this treatment the carthamus loses nearly half its weight. 6633 cwts. of safflower were imported into the United Kingdom in 1835, of which 2930 cwts. were retained for internal consumption.

CASE-HARDENING is the name of the process by which iron tools, keys, &c., have their surfaces converted into steel.

Steel when very hard is brittle, and iron alone is for many purposes, as for fine keys, far too soft. It is therefore an important desideratum to combine the hardness of a steely surface with the toughness of an iron body. These requisites are united by the process of case-hardening, which does not differ from the making of steel, except in the shorter duration of the process. Tools, utensils, or ornaments, intended to be polished, are first manufactured in iron and nearly finished, after which they are put into an iron box, together with vegetable or animal charcoal in powder, and cemented for a certain time. This treatment converts the external part into a coating of steel, which is usually very thin, because the time allowed for the cementation is much shorter than when the whole substance is intended to be converted. Immersion of the heated pieces into water hardens the surface, which is afterwards polished by the usual methods. Moxon, in his *Mechanic Exercises*, p. 56, gives the following receipt for case-hardening:—" Cow's horn or hoof is to be baked or thoroughly dried and pulverized. To this add an equal quantity of bay salt; mix them with stale chamber-ley or white wine vinegar: cover the iron with this mixture, and bed it with the same in loam, or enclose it in an iron box; lay it on the hearth of the forge to dry and harden: then put it into the fire, and blow till the lump have a blood-red heat, and no higher, lest the mixture be burnt too much. Take the iron out, and immerse it in water to harden." I consider the vinegar to be quite superfluous.

I shall now describe the recent application of prussiate (ferrocyanate) of potash to this purpose. The piece of iron, after being polished, is to be made brightly red-hot, and then rubbed or sprinkled over with the above salt in fine powder, upon the part intended to be hardened. The prussiate being decomposed, and apparently dissipated, the iron is

to be quenched in cold water. If the process has been well managed, the surface of the metal will have become so hard as to resist the file. Others propose to smear over the surface of the iron with loam made into a thin paste with a strong solution of the prussiate, to dry it slowly, then expose the whole to a nearly white heat, and finally plunge the iron into cold water, when the heat has fallen to dull redness. See STEEL.

CASHMERE or CACHEMERE, a peculiar textile fabric first imported from the kingdom of Cashmere, and now well imitated in France and Great Britain. The material of the Cashmere shawls is the downy wool found about the roots of the hair of the Thibet goat. The year 1819 is remarkable in the history of French husbandry for the acquisition of this breed of goats, imported from the East under the auspices of their government, by the indefatigable courage and zeal of M. Jaubert, who encountered every fatigue and danger to enrich his country with these valuable animals, aided by the patriotism of M. Ternaux, who first planned this importation, and furnished funds for executing it at his own expense and responsibility. He placed a portion of the flock brought by M. Jaubert, at his villa of Saint Ouen, near Paris, where the climate seemed to be very favorable to them, since for several successive years after their introduction M. Ternaux was enabled to sell a great number of both male and female goats. The quantity of fine fleece or down afforded by each animal annually, is from a pound and a half to two pounds.

The wool imported into Europe comes by the way of Casan, the capital of a government of the Russian empire upon the eastern bank of the Wolga; it has naturally a grayish color, but is easily bleached. Its price a few years back at Paris was 17 francs per kilogramme; that is, about 6 shillings the pound avoirdupois. The waste in picking, carding, and spinning, amounts to about one third of its weight.

The mills for spinning Cachemere wool have multiplied very much of late years in France, as appears from the premiums distributed at the exposition of 1834, and the prices of the yarn have fallen from 25 to 30 per cent. notwithstanding their improved fineness and quality. There is a fabric made with a mixture of Cachemere down and spun silk, which is becoming very general. One of the manufacturers, M. Hindenlang, exhibited samples of Cachemere cloth woven with yarn so fine as No. 130 for warp, and No. 228 for weft.

Messrs. Pollino, brothers, of Paris, produced an assortment of Cachemere pieces from 22 to 100 francs the yard, dyed of every fancy shade. Their establishment at Ferté-Bernard occupies 700 operatives, with an hydraulic wheel of 60 horse power.

The oriental Cashmere shawls are woven by processes extremely slow and consequently costly; whence their prices are very high. They are still sold in Paris at from 4,000 to 10,000 francs a piece; and from 100 to 400 pounds sterling in London. It became necessary, therefore, either to rest satisfied with work which should have merely a surface appearance, or contrive economical methods of weaving, to produce the real Cachemere style with much less labor. By the aid of the draw-loom, and still better of the Jacquard loom, M. Ternaux first succeeded in weaving Cachemere shawls perfectly similar to the oriental in external aspect, which became fashionable under the name of French Cachemere. But to construct shawls altogether identical on both sides with the eastern, was a more difficult task, which was accomplished only at a later period by M. Bauson of Paris.

In both modes of manufacture, the piece is mounted by reeding-in the warp for the different leaves of the heddles, as is commonly practised for warps in the Jacquard looms. The weaving of imitation shawls is executed, as usual, by as many shuttles as there are colors in the design, and which are thrown across the warp in the order established by the reader. The greater number of these weft yarns being introduced only at intervals into the web, when the composition of the pattern requires it, they remain floating loose at the back of the piece, and are cut afterwards, without affecting in the least the quality of the texture; but there is a considerable waste of stuff in the weaving, which is worked up into carpets.

The weaving of the imitation of real Cachemere shawls is different from the above. The yarns intended to form the weft are not only equal in number to that of the colors of the pattern to be imitated, but besides this, as many little shuttles or pirns (like those used by embroiderers) are filled with these yarns, as there are to be colors repeated in the breadth of the piece; which renders their number considerable when the pattern is somewhat complicated and loaded with colors. Each of these small bobbins or shuttles passes through only that portion of the flower in which the color of its yarn is to appear, and stops at the one side and the other of the cloth exactly at its limit; it then returns upon itself after having crossed the thread of the adjoining shuttle. From this reciprocal intertexture of all the yarns of the shuttles, it results, that although the weft is composed of a great many different threads, they no less constitute a continuous line in the whole breadth of the web, upon which the lay or batten acts in the ordinary way

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We see, therefore, that the whole art of manufacturing this Cachemere cloth consists in avoiding the confusion of the shuttles, and in not striking up the lay till all have fulfilled their function. The labor does not exceed the strength of a woman, even though she has to direct the loom and work the treddles. Seated on her bench at the end opposite to the middle of the beam, she has for aids in weaving shawls from 45 to 52 inches wide, two girl apprentices, whom she directs and instructs in their tasks. About four hundred days of work are required for a Cachemere shawl of that breadth. For the construction of the loom, see JACQUARD. •

In the oriental process, all the figures in relief are made simply with a slender pin without the shuttle used in European weaving. By the Indians the flower and its ground are made with the pirn, by means of an intertwisting, which renders them in some measure independent of the warp. In the Lyons imitation of this style, the leaves of the heddles lift the yarns of the warp, the needles embroider as in lappet weaving, and the flower is united to the warp by the weft thrown across the piece. Thus a great deal of labor is saved, the eye is pleased with an illusion of the loom, and the shawls cost little more than those made by the common fly shuttle.

Considered in reference to their materials, the French shawls present three distinct classes, which characterize the three fabrics of Paris, Lyons, and Nimes.

Paris manufactures the French Cachemere, properly so called, of which both the warp and the weft are the yarn of pure Cachemere down. This web represents with fidelity the figures and the shades of color of the Indian shawl, which it copies; the deception would be complete if the reverse of the piece did not show the cut ends. The Hindoo shawl, also woven at Paris, has its warp in spun silk, which reduces its price without impairing its beauty much.

Lyons, however, has made the greatest progress in the manufacture of shawls. It excels particularly in the texture of its Thibet shawls, the weft of which is yarn spun with a mixture of wool and spun silk.

Nimes is remarkable for the low price of its shawls, in which spun silk, Thibet down, and cotton, are all worked up together.

The value of shawls exported from France in the following years was—

	1831.	1832.	1833.
	Francs.	Francs.	Francs.
Woollen - - - - - -	1,863,147	2,070,926	4,319,601
Cachemere down - -	433,410	655,200	609,900
Spun silk - - - - - -	401,856	351,152	408,824

It appears that M. J. Girard at Sèvres, near Paris, has succeeded best in producing Cachemere shawls equal in stuff and style of work to the oriental, and at a lower price. They have this advantage over the Indian shawls, that they are woven without seams, in a single piece, and exhibit all the variety and the raised effect of the eastern colors. Women and children alone are employed in his factory.

CASK (*Tonneau*, Fr.; *Fass*, Germ.), manufacture of by mechanical power. Mr. Samuel Brown obtained a patent in November, 1825, for certain improvements in machinery for making casks, which seems to be ingenious and worthy of record. His mechanism consists in the first place of a circular saw attached to a bench, with a sliding rest, upon which rest each piece of wood intended to form a stave of a cask is fixed; and the rest being then slidden forward in a curved direction, by the assistance of an adjustable guide, brings the piece of wood against the edge of the rotatory saw, and causes it to be cut into the curved shape required for the edge of the stave. The second feature is an apparatus with cutters attached to a standard, and traversing round with their carrier upon a centre, by means of which the upper and lower edges of the cask are cut round and grooved, called chining, for the purpose of receiving the heads. Thirdly, an apparatus not very dissimilar to the last, by which the straight pieces of wood designed for the heads of the cask are held together, and cut to the circular figure required, and also the bevelled edges produced. And fourthly, a machine in which the cask is made to revolve upon an axis, and a cutting tool to traverse for the purpose of shaving the external part of the cask, and bringing it to a smooth surface.

The pieces of wood intended to form the staves of the cask, having been cut to their required length and breadth, are placed upon the slide-rest of the first mentioned machine, and confined by cramps; and the guide, which is a flexible bar, having been previously bent to the intended curve of the stave and fixed in that form, the rest is then slidden forward upon the bench by the hand of the workman, which as it advances (moving in a curved direction) brings the piece of wood against the edge of the revolving circular saw, by which it is cut to the curved shape desired.

The guide is a long bar held by a series of moveable blocks fitted to the bench by

screws, and is bent to any desired curve by shifting the screws: the edge of the slide-rests which holds the piece of wood about to be cut, runs against the long guide bar, and of consequence is conducted in a corresponding curved course. The circular saw receives a rapid rotatory motion by means of a band or rigger from any first mover; and the piece of wood may be shifted laterally by means of racks and pinions on the side-rest, by the workman turning a handle, which is occasionally necessary in order to bring the piece of wood up to, or away from, the saw.

The necessary number of staves being provided, they are then set round within a confining hoop at bottom, and brought into the form of a cask in the usual way, and braced by temporary hoops. The barrel part of the cask being thus prepared, in order to effect the chining, it is placed in a frame upon a platform, which is raised up by a treddle lever, that the end of the barrel may meet the cutters in a sort of lathe above: the cutters are then made to traverse round within the head of the barrel, and, as they proceed, occasionally to expand, by which means the bevels and grooves are cut on the upper edge of the barrel, which is called chining. The barrel being now reversed, the same apparatus is brought to act against the other end, which becomes chined in like manner.

The pieces of wood intended to form the heads of the cask are now to be cut straight by a circular saw in a machine, similar to the first described; but in the present instance the slide-rest is to move forward in a straight course. After their straight edges are thus produced, they are to be placed side by side, and confined, when a scribing cutter is made to traverse round, and cut the pieces collectively into the circular form desired for heading the cask.

The cask having now been made up, and headed by hand as usual, it is placed between centres, or upon an axle in a machine, and turned round by a rigger or band with a shaving cutter, sliding along a bar above it, which cutter, being made to advance and recede as it slides along, shaves the outer part of the cask to a smooth surface.

CASSAVA. *Cassava bread, conaque, &c.,* are different names given to the starch of the root of the Manioc (*Jatropha Manihot,* Linn.), prepared in the following manner in the West Indies, the tropical regions of America, and upon the African coast. The tree belongs to the natural family of the *euphorbiaceæ.*

The roots are washed, and reduced to a pulp by means of a rasp or grater. The pulp is put into coarse strong canvass bags, and thus submitted to the action of a powerful press, by which it parts with most of its noxious juice (used by the Indians for poisoning the barbs of their arrows.) As the active principle of this juice is volatile, it is easily dissipated by baking the squeezed cakes of pulp upon a plate of hot iron. Fifty pounds of the fresh juice, when distilled, afford, at first, three ounces of a poisonous water, possessing an intolerably offensive smell; of which, 35 drops being administered to a slave convicted of the crime of poisoning, caused his death in the course of six minutes, amid horrible convulsions.[*]

The pulp dried in the manner above described concretes into lumps, which become hard and friable as they cool. They are then broken into pieces, and laid out in the sun to dry. In this state they afford a wholesome nutriment, and are habitually used as such by the negroes, as also by many white people. These cakes constitute the only provisions laid in by the natives, in their voyages upon the Amazons. Boiled in water with a little beef or mutton they form a kind of soup similar to that of rice.

The cassava cakes sent to Europe (which I have eaten with pleasure) are composed almost entirely of starch, along with a few fibres of the ligneous matter. It may be purified by diffusion through warm water, passing the milky mixture through a linen cloth, evaporating the strained liquid over the fire, with constant agitation. The starch dissolved by the heat, thickens as the water evaporates, but on being stirred, it becomes granulated, and must be finally dried in a proper stove. Its specific gravity is 1·530 — that of the other species of starch.

The product obtained by this treatment is known in commerce under the name of *tapioca;* and being starch very nearly pure, is often prescribed by physicians as an aliment of easy digestion. A tolerably good imitation of it is made by heating, stirring, and drying potato starch in a similar way.

The expressed juice of the root of manioc contains in suspension a very fine fecula, which it deposites slowly upon the bottom of the vessels. When freed by decantation from the supernatant liquor, washed several times and dried, it forms a beautiful starch, which creaks on pressure with the fingers. It is called *cipipa,* in French Guyana; it is employed for many delicate articles of cookery, especially pastry, as also for hair powder, starching linen, &c.

Cassava flour, as imported, may be distinguished from arrow-root and other kinds

of starch, by the appearance of its particles viewed in a microscope. They are spherical, all about 1-1000th of an inch in diameter, and associated in groups; those of potato starch are irregular ellipsoids, varying in size from 1-300th to 1-3000th of an inch; those of arrow-root have the same shape nearly, but vary in size from 1-500th to 1-800th of an inch; those of wheat are separate spheres 1-1000th of an inch.

CASSIS, the black currant (*ribes nigra*, Linn.), which was formerly celebrated for its medicinal properties, with very little reason.

The only technical use to which it is now applied is in preparing the agreeable *liqueur* called *ratafia*, by the following French recipe:—Stone, and crush three pounds of black currants, adding to the magma one drachm of cloves, two of cinnamon, four quarts of spirit of wine, at 18° Baumé (see AREOMETRE OF BAUME), and 2¼ pounds of sugar. Put the mixture into a bottle which is to be well corked; let it digest for a fortnight, shaking the bottle once daily during the first eight days; then strain through a linen cloth, and finally pass through filtering paper.

CASTING OF METALS. (See FOUNDING.) *Casts from elastic moulds.*—Being much engaged in taking casts from anatomical preparations, Mr. Douglas Fox, Surgeon, Derby, found great difficulty, principally with hard bodies, which, when undercut, or having considerable overlaps, did not admit of the removal of moulds of the ordinary kind, except with injury. These difficulties suggested to him the use of elastic moulds, which, giving way as they were withdrawn from complicated parts, would return to their proper shape; and he ultimately succeeded in making such moulds of glue, which not only relieved him from all his difficulties, but were attended with great advantages, in consequence of the small number of pieces into which it was necessary to divide the mould.

The body to be moulded, previously oiled, must be secured one inch above the surface of a board, and then surrounded by a wall of clay, about an inch distant from its sides. The clay must also extend rather higher than the contained body: into this, warm melted glue, as thick as possible so that it will run, is to be poured, so as to completely cover the body to be moulded; the glue is to remain till cold, when it will have set into an elastic mass, just such as is required.

Having removed the clay, the glue is to be cut into as many pieces as may be necessary for its removal, either by a sharp-pointed knife, or by having placed threads in the requisite situations of the body to be moulded, which may be drawn away when the glue is set, so as to cut it out in any direction.

The portions of the glue mould having been removed from the original, are to be placed together and bound round by tape.

In some instances it is well to run small wooden pegs through the portions of glue, so as to keep them exactly in their proper positions. If the mould be of considerable size, it is better to let it be bound with moderate tightness upon a board to prevent it bending whilst in use; having done as above described, the plaster of Paris, as in common casting, is to be poured into the mould, and left to set.

In many instances wax may also be cast in glue, if it is not poured in whilst too hot as the wax cools so rapidly when applied to the cold glue, that the sharpness of the impression is not injured.

Glue has been described as succeeding well where an elastic mould is alone applicable; but many modifications are admissible. When the moulds are not used soon after being made, treacle should be previously mixed with the glue (as employed by printers) to prevent it becoming hard.

The description thus given is with reference to moulding those bodies which cannot be so done by any other than an elastic mould; but glue moulds will be found greatly to facilitate casting in many departments, as a mould may be frequently taken by this method in two or three pieces, which would on any other principle require many.

CASTOR. (Eng. and Fr.; *Biber*, Germ.) The castor is an amphibious quadruped, inhabiting North America; also found in small numbers in the islands of the Rhone. In the arts, the skin of this animal is employed either as a fur or as affording the silky hair called beaver, with which the best hats are covered. Beaver skins, which form a very considerable article of trade, are divided into 3 sorts: 1. The fresh beaver skins from castors, killed in winter before shedding their hair; these are most in request among the furriers, as being the most beautiful. 2. The dry or lean beavers are the skins of the animals killed during the moulting season; they are not much esteemed, as the skin is rather bare. 3. The fat castors: these are the skins of the first sort, which have been worn for some time upon the persons of the savages, and have got imbued with their sweat. The last are principally used in the hat manufacture. In France, the marine otter has been for many years substituted in the place of the castor or beaver.

CASTOR or CASTOREUM. This name is given to a secretion of the castor

contained in pear-shaped cellular organic sacs, placed near the genital organs of both the male and female animals. It is a substance analogous to civet and musk, of a consistence similar to thick honey. It has a bitter acrid taste; a powerful, penetrating, fetid, and very volatile smell; but, when dried, it becomes inodorous. Several chemists, and in particular Bouillon Lagrange, Laugier, and Hildebrandt, have examined castor, and found it to be composed of a resin, a fatty substance, a volatile oil, an extractive matter, benzoic acid, and some salts.

The mode of preparing it is very simple. The sacs are cut off from the castors when they are killed, and are dried to prevent the skin being affected by the weather. In this state, the interior substance is solid, of a dark color, and a faint smell; it softens with heat, and becomes brittle by cold. Its fracture betrays fragments of membranes, indicating its organic structure. When chewed, it adheres to the teeth somewhat like wax; it has a bitter, slightly acrid, and nauseous taste.

The castor bags, as imported, are often joined in pairs by a kind of ligature. Sometimes the substance which constitutes their value is sophisticated; a portion of the castoreum being extracted, and replaced by lead, clay, gums, or some other foreign matters. This fraud may be easily detected, even when it exists in a small degree, by the absence of the membranous partitions in the interior of the bags, as well as by the altered smell and taste.

The use of castoreum in medicine is considerable, especially in nervous and spasmodic diseases, and it is often advantageously combined with opium.

CASTORINE. A chemical principle lately discovered to the amount of a few parts per cent. in Castoreum.

CASTOR OIL. The expressed oil of the seeds of the *Palma Christi*, or *Ricinus communis*, a native tree of the West Indies and South America; but which has been cultivated in France, Italy, and Spain. Bussy and Lecanu discovered in it 3 species of fatty matters, obtained partly by saponification, and partly by dry distillation—the margaritic, ricinic, and elaiodic acids. None of these has been separately applied to any use in the arts.

The quantity of castor oil imported in 1835 into the United Kingdom was 1,109,307 lbs.; retained for home consumption, 670,205 lbs. See OILS.

CATECHU, absurdly called Terra Japonica, is an extract made from the wood of the tree *mimosa catechu*, which grows in Bombay, Bengal, and other parts of India. It is prepared by boiling the chips of the interior of the trunk in water, evaporating the solution to the consistence of sirup over the fire, and then exposing it in the sun to harden. It occurs in flat rough cakes, and under two forms. The first, or the Bombay, is of uniform texture, of a dark red color, and of specific gravity 1·39. The second is more friable and less solid. It has a chocolate color, and is marked inside with red streaks. Its specific gravity is 1·28.

According to Sir H. Davy, these two species are composed as follows:—

	Bombay.	Bengal.
Tannin - - - - - - -	54·5	48·5
Extractive - - - - -	34·0	36·5
Mucilage - - - - - -	6·5	8
Insoluble matters, sand and lime - -	5	7
	100·0	100·0

Areka nuts are also found to yield catechu; for which purpose they are cut into pieces watered in an earthen pot with solution of nitre, and have a little of the bark of a species of mimosa added to them. The liquor is then boiled with the nuts, and affords an inspissated decoction.

Good catechu is a brittle, compact solid, of a dull fracture. It has no smell, but a very astringent taste. Water dissolves the whole of it, except the earthy matter, which is probably added during its preparation. Alcohol dissolves its tannin and extractive. The latter may be oxydized, and thus rendered insoluble in alcohol, by dissolving the catechu in water, exposing it for some time to a boiling heat, and evaporating to dryness.

The tannin of catechu differs from that of galls, in being soluble in alcohol, and more soluble in water. It precipitates iron of an olive color, and gelatin in a mass which gradually becomes brown.

It has been long employed in India for tanning skins, where it is said to effect this object in five days. I have seen a piece of sole leather completely tanned by it in this country in ten days, the ox-hide having been made into a bag, with the hair outside, and kept filled with the solution of catechu. In India it has also been used to give a brown dye to

cotton goods, and of late years it has been extensively introduced into the calico print-works of Europe. The salts of copper with sal ammoniac cause it to give a bronze color, which is very fast; the proto-muriate of tin, a brownish yellow; the per-chloride of tin, with the addition of nitrate of copper, a deep bronze hue; acetate of alumina alone, a reddish brown, and, with nitrate of copper, a reddish olive gray; nitrate of iron, a dark brown gray. For dyeing a golden coffee brown, it has entirely superseded madder; one pound of it being equivalent to six pounds of this root.

A solution of one part of catechu in ten parts of water, which is reddish brown, exhibits the following results: with—

Acids - - - -	- A brightened shade.
Alkalis - - -	- A darkened shade.
Proto-sulphate of iron	- Olive brown precipitate.
Per-sulphate of iron	- Olive green do.
Sulphate of copper -	- Yellowish brown.
Alum - - -	- A brightening of the liquor.
Per-nitrate of iron -	- Olive green precipitate.
Nitrate of copper -	- Yellowish brown do.
Nitrate of lead -	- Salmon do.
Proto-nitrate of mercury -	- Milk-coffee do.
Muriate of alumina	- Brown-yellow.
Muriate of tin -	- Do. do.
Per-chloride of tin -	- Do. darker.
Corrosive sublimate	- Light chocolate do.
Acetate of alumina -	- Brightening of the liquor.
Acetate of copper -	- Copious brown precipitate
Acetate of lead -	- Salmon colored do.
Bichromate of potash	- Copious brown do.

Pure tannin may be obtained from catechu, by treating it with sulphuric acid and carbonate of lead; but this process has no manufacturing application.

CATGUT (*Corde à boyau*, Fr.; *Darmsaite*, Germ.), the name absurdly enough given to cords made of the twisted intestines of the sheep. The guts being taken while warm out of the body of the animal, are to be cleared of feculent matter, freed from any adhering fat, and washed in a tub of water. The small ends of all the intestines are next to be tied together, and laid on the edge of the tub, while the body of them is left to steep in some water, frequently changed, during two days, in order to loosen the peritoneal and mucous membranes. The bundle of intestines is then laid upon a sloping table which overhangs the tub, and their surface is scraped with the back of a knife, to try if the external membrane will come away freely in breadths of about half the circumference. This substance is called by the French manufacturers *filandre*, and the process *filer*. If we attempt to remove it by beginning at the large end of the intestine, we shall not succeed. This *filandre* is employed as thread to sew intestines, and to make the cords of rackets and battledoors. The flayed guts are put again into fresh water, and, after steeping a night, are taken out and scraped clean next day, on the wooden bench with the rounded back of a knife. This is called *curing the gut*. The large ends are now cut off, and sold to the pork-butchers. The intestines are again steeped for a night in fresh water, and the following day in an alkaline lixivium made by adding 4 ounces of potash, and as much pearl-ash, to a pail of water containing about 3 or 4 imperial gallons. This ley is poured in successive quantities upon the intestines, and poured off again, after 2 or 3 hours, till they be purified. They are now drawn several times through an open brass thimble, and pressed against it with the nail, in order to smooth and equalize their surface. They are lastly sorted, according to their sizes, to suit different purposes.

Whip-cord is made from the above intestines, which are sewed together endwise by the *filandre*, each junction being cut aslant, so as to make it strong and smooth. The cord is put into the frame, and each end is twisted separately; for whip-cord is seldom made out of two guts twisted together. When twisted, it is to be sulphured (see SULPHURING) once or twice. It may also be dyed black with common ink, pink with red ink, which the sulphurous acid changes to pink, and green with a green dye which the color dealers sell for the purpose. The guts take the dyes readily. After being well smoothed, the cord is to be dried, and coiled up for sale.

Hatters' cords for bowstrings.—The longest and largest intestines of sheep, after being properly treated with the potash, are to be twisted 4, 6, 8, 10, or 12 together, according to the intended size of the cord, which is usually made from 15 to 25 feet long. This cord must be free from seams and knots. When half dry, it must be exposed twice to the fumes of burning sulphur; and, after each operation, it is to be well stretched and smoothed: it should be finally dried in a state of tension.

Clockmaker's cord.—This cord should be extremely thin, and be therefore made from

ry small intestines, or from intestines slit up in their length by a knife fitted for the
rpose; being a kind of lancet surmounted with a ball of lead or wood. The wet gut
strained over the ball which guides the knife, and the two sections fall down into a
ssel placed beneath. Each hand pulls a section. Clockmakers also make use of
onger cords made of 2 or more guts twisted together.

Fiddle and harp strings. — These require the greatest care and dexterity on the part
the workmen. The treble strings are peculiarly difficult to make, and are best made
Naples, probably because their sheep, from their small size and leanness, afford the
st raw material.

The first scraping of the guts intended for fiddle-strings must be very carefully performed;
d the alkaline leys, being clarified with a little alum, are added, in a progressively stronger
ate from day to day, during 4 or 5 days, till the guts be well bleached and swollen.
hey must then be passed through the thimble, and again cleansed with the lixivium;
ter which they are washed, spun, or twisted and sulphured during two hours. They are
ally polished by friction, and dried. Sometimes they are sulphured twice or thrice
fore being dried, and are polished between horse-hair cords.

It has been long a subject of complaint, as well as a serious inconvenience to mu-
cians, that catgut strings cannot be made in England of the same goodness and strength
those imported from Italy. These are made of the peritoneal covering of the in-
stines of the sheep; and, in this country, they are manufactured at Whitechapel, and
obably elsewhere in considerable quantity; the consumption of them for harps, as
ell as for the instruments of the violin family, being very great. Their chief fault is
eakness; whence it is difficult to bring the smaller ones, required for the higher notes,
concert pitch; maintaining at the same time, in their form and construction, that
nuity or smallness of diameter, which is required to produce a brilliant and clear tone.
The inconvenience arising from their breaking when in use, and the expense in the
se of harps, where so many are required, are such as to render it highly desirable to
prove a manufacture which, to many individuals may, however, appear sufficiently con-
mptible.

It is well known to physiologists, that the membranes of lean animals are far more
ugh than of those animals which are fat or in high condition; and there is no reason to
ubt that the superiority of the Italian strings arises from the state of the sheep in that
untry. In London, where no lean animals are slaughtered, and where, indeed, an
travagant and useless degree of fattening, at least for the purpose of food, is given to
eep in particular, it is easy to comprehend why their membranes can never afford a
aterial of the requisite tenacity. It is less easy to suggest an adequate remedy; but a
nowledge of the general principle, should this notice meet the eyes of those interested in
e subject, may at least serve the purpose of diminishing the evil and improving the ma-
nfacture, by inducing them to choose in the market the offal of such carcasses as appear
ast overburdened with fat. It is probable that such a manufacture might be advan-
geously established in those parts of the country where the fashion has not, as in
ondon, led to the use of meat so much overfed; and it is equally likely, that in the
oice of sheep for this purpose, advantage would arise from using the Welch, the High-
nd, or the Southdown breeds, in preference to those which, like the Lincoln, are prone
excessive accumulations of fat. It is equally probable, that sheep dying of some
f the diseases accompanied by emaciation, would be peculiarly adapted to this
r, se.

That these suggestions are not merely speculative is proved by comparing the strength
f the membranes in question, or that of the other membranous parts, in the unfattened
ighland sheep, with that of those found in the London markets.

CATHARTINE. The name proposed by MM. Feneulle and Lassaigne for a chemi-
l principle, which they suppose to be the active constituent of senna.

CAUSTIC. Any chemical substance corrosive of the skin and flesh; as potash, called
mmon caustic, and nitrate of silver, called lunar caustic, by surgeons.

CAVIAR. The salted roe of certain species of fish, especially the sturgeon. This
oduct forms a considerable article of trade, being exported annually from the town of
trachan alone, upon the shores of the Caspian sea, to the amount of several hundred
s. The Italians first introduced it into Eastern Europe from Constantinople, under
name of *cariale.* Russia has now monopolized this branch of commerce. It is pre-
red in the following manner: —

The female sturgeon is gutted; the roe is separated from the other parts, and cleaned
passing it through a very fine searce, by rubbing it into a pulp between the hands;
is is afterwards thrown into tubs, with the addition of a considerable quantity of salt;
e whole is then well stirred, and set aside in a warm apartment. There is another
rt of caviar, the compressed, in which the roe, after having been cured in strong brine,
dried in the sun, then put into a cask, and subjected to strong pressure.

CAWK. The English miner's name for sulphate of baryta, or heavy spar.

CEDRA (*Cedrat*, Fr.) is the fruit of a species of orange, citron, or lemon, a tree which bears the same name. Its peel is very thick, and covered with an epidermis which encloses a very fragrant and highly prized essential oil. The preserves flavored with it are very agreeable. The citrons are cut into quarters for the dry comfits, but are put whole into the liquid ones. The liquorist-perfumer makes with the peel of the *cedra* an excellent *liqueur;* for which purpose, he plucks them before they are quite ripe; grates down the peel into a little brandy, or cuts them into slices, and infuses these in the spirits. This infusion is distilled for making perfume; but the flavor is better when the infusion itself is used. See ESSENCES, LIQUORIST, PERFUMERY.

CELESTINE. Native sulphate of strontia, found abundantly near Bristol, in the red marl formation. It is decomposed, by ignition with charcoal, into sulphuret of strontia, which is converted into nitrate by saturation with nitric acid, evaporation, and crystallization. This nitrate is employed for the production of the red light in theatrical fire-works.

CEMENTATION. A chemical process, which consists in imbedding a solid body in a pulverulent matter, and exposing both to ignition in an earthen or metallic case. In this way, iron is cemented with charcoal to form steel, and bottle glass with gypsum powder, or sand, to form Reaumur's porcelain.

CEMENTS. (*Ciments*, Fr.; *Cämente, Kitte*, Germ.) Substances capable of taking the liquid form, and of being in that state applied between the surfaces of two bodies, so as to unite them by solidifying. They may be divided into two classes, those which are applied through the agency of a liquid menstruum, such as water, alcohol, or oil, and those which are applied by fusion with heat.

The *diamond* cement for uniting broken pieces of china, glass, &c., which is sold as a secret at an absurdly dear price, is composed of isinglass soaked in water till it becomes soft, and then dissolved in proof spirit, to which a little gum resin, ammoniac, or galbanum, and resin mastic are added, each previously dissolved in a minimum of alcohol. When to be applied, it must be gently heated to liquefy it; and it should be kept for use in a well-corked vial. A glass stopper would be apt to fix so as not to be removeable. This is the cement employed by the Armenian jewellers in Turkey for glueing the ornamental stones to trinkets of various kinds. When well made it resists moisture.

Shellac dissolved in alcohol, or in a solution of borax, forms a pretty good cement. White of egg alone, or mixed with finely sifted quicklime, will answer for uniting objects which are not exposed to moisture. The latter combination is very strong, and is much employed for joining pieces of spar and marble ornaments. A similar composition is used by copper-smiths to secure the edges and rivets of boilers; only bullock's blood is the albuminous matter used instead of white of egg. Another cement in which an analogous substance, the curd or caseum of milk is employed, is made by boiling slices of skim-milk cheeses into a gluey consistence in a great quantity of water, and then incorporating it with quicklime on a slab with a muller, or in a marble mortar. When this compound is applied warm to broken edges of stoneware, it unites them very firmly after it is cold.

A cement which gradually indurates to a stony consistence may be made by mixing 20 parts of clean river sand, two of litharge, and one of quicklime, into a thin putty with linseed oil. The quicklime may be replaced with litharge. When this cement is applied to mend broken pieces of stone, as steps of stairs, it acquires after some time a stony hardness. A similar composition has been applied to coat over brick walls, under the name of mastic.

The iron-rust cement is made of from 50 to 100 parts of iron borings, pounded and sifted, mixed with one part of sal-ammoniac, and when it is to be applied moistened with as much water as will give it a pasty consistency. Formerly flowers of sulphur were used, and much more sal-ammoniac in making this cement, but with decided disadvantage, as the union is effected by the oxydizement, consequent expansion and solidification of the iron powder, and any heterogeneous matter obstructs the effect. The best proportion of sal-ammoniac is, I believe, one per cent. of the iron borings. Another composition of the same kind is made by mixing 4 parts of fine borings or filings of iron, 2 parts of potter's clay, and 1 part of pounded potsherds, and making them into a paste with salt and water. When this cement is allowed to concrete slowly on iron joints, it becomes very hard.

For making architectural ornaments in relief, a moulding composition is formed of chalk, glue, and paper paste. Even statues have been made with it, the paper aiding the cohesion of the mass.

Mastics of a resinous or bituminous nature which must be softened or fused by heat are the following: —

Mr. S. Varley's consists of sixteen parts of whiting sifted and thoroughly dried by a red heat, adding when cold a melted mixture of 16 parts of black rosin and 1 of bees'-wax, and stirring well during the cooling.

. Singer's electrical and chemical apparatus cement consists of 5 lbs. of rosin, 1 of wax, 1 of red ochre, and two table-spoonsful of Paris plaster, all melted together. aper one for cementing voltaic plates into wooden troughs is made with 6 pounds in, 1 pound of red ochre, ¼ of a pound of plaster of Paris, and ¼ of a pound of lin-bil. The ochre and the plaster of Paris should be calcined beforehand, and added : other ingredients in their melted state. The thinner the stratum of cement that erposed, the stronger, generally speaking, is the junction.

lled linseed oil and red lead mixed together into a putty are often used by copper-s and engineers, to secure joints. The washers of leather or cloth are smeared this mixture in a pasty state.

le resin mastic alone is sometimes used by jewellers to cement by heat cameos of : enamel or colored glass to a real stone, as a ground to produce the appearance of yx. Mastic is likewise used to cement false backs or doublets to stones, to alter hue.

elted brimstone, either alone, or mixed with rosin and brick dust, forms a tolerably and very cheap cement.

amber's cement consists of black rosin one part, brick dust two parts, well incorpo-by a melting heat.

le cement of dihl for coating the fronts of buildings consists of linseed oil, rendered y boiling with litharge, and mixed with porcelain clay in fine powder, to give it the stence of stiff mortar. Pipe-clay would answer equally well if well dried, and any might be given with ground bricks, or pottery. A little oil of turpentine to thin cement aids its cohesion upon stone, brick, or wood. It has been applied to sheets ire cloth, and in this state laid upon terraces, in order to make them water tight; but little less expensive than lead.

le bituminous or black cement for bottle-corks consists of pitch hardened by the ad-a of rosin and brick-dust.

certain localities where a limestone impregnated with bitumen occurs, it is dried, ad, sifted, and then mixed with about its own weight of melted pitch, either mineral, table, or that of coal tar. When this mixture is getting semifluid, it may be moulded large slabs or tiles in wooden frames lined with sheet iron, previously smeared over common lime mortar, in order to prevent adhesion to the moulds, which, being in able pieces, are easily dismounted so as to turn out the cake of artificial bituminous :. This cement is manufactured upon a great scale in many places, and used for ng Italian terraces, covering the floors of balconies, flat roofs, water reservoirs, water its, &c. When laid down, the joints must be well run together with hot irons. The of the terrace should be previously covered with a layer of Paris plaster or common ar, nearly an inch thick, with a regular slope of one inch to the yard. Such bitumin-cement weighs 144 pounds the cubic foot; or a foot of square surface, one inch thick, hs 12 pounds. Sometimes a second layer of these slabs or tiles is applied over the with the precaution of making the seams or joints of the upper correspond with the le of the under ones. Occasionally a bottom bed, of coarse cloth or gray paper, is led. The larger the slabs are made, as far as they can be conveniently transported aid down, so much the better. For *hydraulic* cements, see MORTAR.

ERASIN. The name given by Dr. John to those gums which swell, but do not lve in water; such as gum tragacanth. It is synonymous with BASSORINE, h see.

ERATE, from *cera*, *wax*. An unguent, of rather a stiff consistence, made of oil, or and wax, thickened occasionally with pulverulent matters.

ERINE. A substance which forms from 70 to 80 per cent. of bees'-wax. It may btained by digesting wax, for some time, in spirit of wine, at a boiling temperature. *myricine* separates, while the *cerine* remains dissolved, and may be obtained from decanted liquor by evaporation. Cerine is white, analogous to wax, fusible at F., hardly acted upon by hot nitric acid, but is readily carbonized by hot sul-ic acid. When treated with caustic alkaline ley, it is converted into margaric acid *eraine*.

ERIUM. A peculiar metal discovered in the rare mineral, called *cerite*, found in the copper mine of Bastnaes, near Riddarhytta, in Sweden. Cerium, extracted its chloride by potassium, appears as a dark red or chocolate powder, which as-s a metallic lustre by friction. It does not conduct electricity well, like other ls; it is infusible; its specific gravity is unknown. It has been applied to no use e arts.

ERUSE. A name of white lead. See LEAD.

ETINE. The name given by Chevreul to spermaceti.

HAINWORK is a peculiar style of textile fabric, to which hosiery and tambouring ng. See HOSIERY.

HALK. (*Craie*, Fr.; *Kreide*, Germ.) A friable carbonate of lime, white, opaque,

soft, dull, or without any appearance of polish in its fracture. Its specific gravity varies from 2·4 to 2·6. It usually contains a little silica, alumina, and oxyde of iron. It may be purified by trituration and elutriation. The silicious and ferruginous matters subside first, and the finer chalky particles floating in the supernatant liquid, may be decanted with it, and obtained by subsidence. When thus purified, it is called *whitening* and Spanish white, in England; *schlemmkreide*, in Germany; *blanc de Troyes*, and *blanc de Meudon*, in France. Pure chalk should dissolve readily in dilute muriatic acid, and the solution should afford no precipitate with water of ammonia.

CHALK-*Black*. A mineral, called also *drawing-slate*.

CHALK-*French*. *Steatite*, or soap-stone; a soft magnesian mineral.

CHALK-*Red*. A clay colored with the peroxyde of iron, of which it contains about 17 per cent.

CHARCOAL. The fixed residuum of vegetables exposed to ignition out of contact of air. In the article CARBON, I have described the general properties of charcoal and the simplest mode of making it. I shall here detail the best systems of manufacturing this product upon the continent of Europe.

To carbonize wood under a moveable covering, the plan of *meiler*, or heaps, is employed very much in Germany. The wood is arranged either in horizontal layers, or in nearly vertical ones, with a slight slope, so as to form conical rounded heaps of different sizes. The former are called lying *meiler*, *fig.* 272; the latter standing *meiler*, *figs.* 273. and 274.

272   273   ·   274

Both are distributed in much the same way.

In districts where the wood can be transported into one place by means of rivers, or mountain-slides, a dry flat space must be pitched upon, screened from storms and floods, which may be walled round, having a slight declivity made in the ground, toward the centre. See *fig.* 275. Into this space the tarry acid will partially fall, and may be conducted outward, through a covered gutter beneath, into a covered tank. The mouth of the tank must be shut, during the coaking, with an iron or stone slab, luted with clay. A square iron plate is placed over the inner orifice of the gutter, to prevent it being choked with coal ashes.

275   d
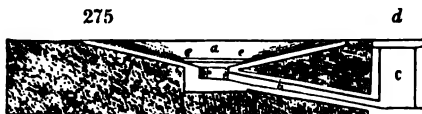
Fig. 275 represents a walled *meiler* station; *a*, the station; *b*, the gutter; *c*, the tank, which is covered with the slab *d*; *e*, a slab which serves to keep the gutter clear of coals. The cover of the heaps is formed of earth, sand, ashes, or such other matter as may be most readily found in the woods. They should be kindled in the centre. From 6 days to 4 weeks may be required for charring a heap, according to its size; hard wood requiring most time; and the slower the process, the better and greater is the product, generally speaking.

276
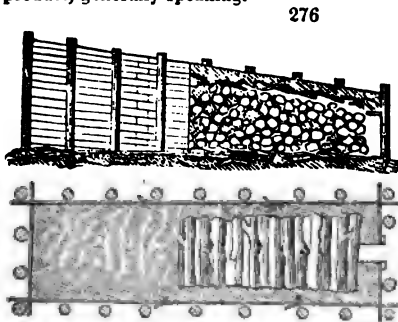
Charring of wood in mounds (*Haufe* or *liegende werke*), figs. 276 and 277, differs from that in the *meiler*, because the wood in the *haufe* is successively charred, and the charcoal is raked out by little and little. The product is said to be greater in this way, and also better. Uncleft billets, 6 or feet long, being laid over each other, are covered with ashes, and then carbonized. The station sometimes horizontal, and sometimes made to slope. The length may be 24 feet, the breadth feet; and the wood is laid cross

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vise. Piles are set perpendicularly to support the roof, made of boughs and leaves, covered with ashes. Pipes are occasionally laid within the upper part of the mounds, which serve to catch and carry off some of the liquid products into proper tanks.
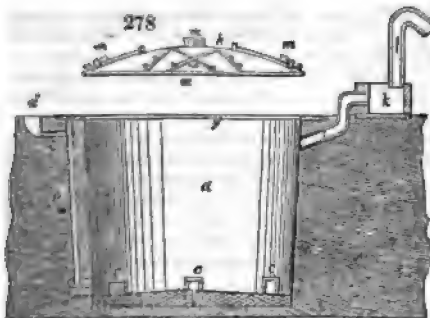
Fig. 278 is a vertical section, and *fig.* 279, a half bird's-eye view, and half cross section, at the height of the pit-bottom, of Chabeaus-siere's kiln for making wood charcoal. *a* is the oven; *b*, vertical air-pipes; *c c*, horizontal flues for admitting air to the kiln; *d d*, small pits which communicate by short horizontal pipes *e e*, with the vertical ones; *f*, the sole of the kiln, a circle of brickwork, upon which the cover or hood *h* reposes; *i*, a pipe which leads to the cistern *k*; *l*, the pipe destined for carrying off the gaseous matter; *m m*, holes in the iron cover or lid.
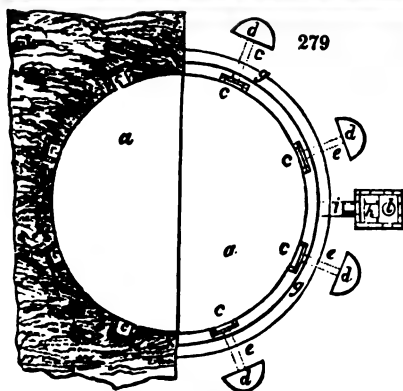
The distribution of the wood is like that in the horizontal *meilers*, or heaps; it is kindled in the central vertical canal with burning fuel, and the lid is covered with a few inches of earth. At the beginning of the operation all the draught flues are left open, but they are progressively closed, as occasion requires. In eight kilns of this kind, 500 *decasters* of oak wood are carbonized, from which 16,000 hectolitres of charcoal are obtained, equal to 64,000 pounds French, being about 25 per cent.; besides tar and 3000 velts of wood vinegar, of from 2° to 3° *Baumé*.

At Crouy upon the Ourcq, near Meaux, there is a well-constructed kiln for making turf-charcoal. It resembles most nearly a tar-kiln. In *fig.* 280, *a* is the cylindrical coaking place, whose surrounding walls are heated by the flame which passes through the intermediate space *b*. The place itself is divided by partitions of fire tiles into three stages, through the apertures in which the flames of the fire *c c*, rise, and heat the exterior of the coaking apartment. In order to confine the heat, there is in the enclosing walls of the outer kiln a cylindrical hollow space *d*, where the air is kept stagnant. Through the apertures left in the upper end at *e*, the turf is introduced; they are then shut with an iron plate *f*, which is covered with ashes or sand. The fire-place opens above this aperture, and its outlet is provided with a moveable iron cover *g*, in which there is a small hole for the issue of the gases. The sole of the kiln consists of a cast iron slab *h*, which may be raised by means of a hook *i* upon it. This is drawn back after the carbonization is completed, whereby the charcoal falls from the coaking space into a subjacent vault. The volatile products are carried off by the pipe *k*, and led into the condensing cistern; the gases escaping to the fire-place where they are burned. The iron slab is protected from the corrosion of the acid vapors by a layer of coal ashes.
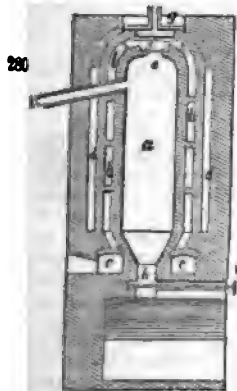
CHICA is a red coloring principle made use of in America by some Indian tribes to stain their skins. It is extracted from the *bignonia chica* by boiling its leaves in water, decanting the decoction, and allowing it to settle and cool, when a red matter falls down, which is formed into cakes and dried. This substance is not fusible, and

when burned, diffuses the same odor as animal bodies do.   t is insoluble in cold water, very soluble in alcohol and ether, but after the evaporation of these liquids, it is recovered unchanged. Fats and unctuous oils both dissolve it. It is soluble in carbonated and caustic alkaline leys, from which it is precipitated by the acids without alteration. An excess of alkali, however, speedily decomposes it. Nitric acid transforms it into oxalic acid, and a bitter matter. Chlorine makes it white.

The savages mix this pigment with the fat of the cayman or alligator, and rub their skins with the mixture.   It may probably be turned to account in the arts of civilized nations.

CHIMNEY. (*Cheminée*, Fr.; *Schornstein*, Germ.)   Chimney is a modern invention for promoting the draught of fires and carrying off the smoke, introduced into England so late as the age of Elizabeth, though it seems to have been employed in Italy 100 years before. The Romans, with all their luxurious refinements, must have had their Epicurean cookery placed in perpetual jeopardy from their kitchen fires, which, having no vent by a vertical tunnel in the walls, discharged their smoke and frequently their flames at the windows, to the no small alarm of their neighbors, and annoyance of even the street passengers.

Chimneys in dwelling houses serve also the valuable purpose of promoting salubrious circulation of air in the apartments, when not foolishly sealed with anti-ventilating stove-chests.

The first person who sought to investigate the general principles of chimney draughts, in subserviency to manufacturing establishments, was the celebrated Montgolfier. As the ascent of heated air in a conduit depends upon the diminution of its specific gravity, or, in other words, upon the increase of its volume by the heat, the ascensional force may be deduced from the difference between the density of the elastic fluid in the interior of the chimney, and of the external air; that is, between the different heights of the internal and external columns of elastic fluid supposed to be reduced to the same density. In the latter case, the velocity of the gaseous products of combustion in the interior of the chimney is equal to that of a heavy body let fall from a height equal to the difference in height of the two aerial columns.

To illustrate this position by an example, let us consider the simple case of a chimney of ventilation for carrying off foul air from a factory of any kind; and suppose that the tunnel of iron be incased throughout with steam at 212 degrees Fahr. Suppose this tunnel to be 100 yards high, then the weight of the column of air in it will be to that of a column of external air 100 yards high, assumed at 32° F., inversely as its expansion by 180°; that is, as 1000 is to 1·375; or as 72·727 is to 100. The column of external air at 32° being 100 yards, the internal column will be represented by 72·727; and the difference $=27·27$, will be the amount of unbalanced weight or pressure, which is the effective cause of the ventilation. Calculating the velocity of current due to this difference of weight by the well-known formula for the fall of heavy bodies, that is to say, multiplying the above difference, which is 27·27, by the constant factor 19.62, and extracting the square root of the product; thus $\sqrt{19·62 \times 27·27} = 23·13$ will be the velocity in yards per second, which, multiplied by 3, gives 60·30 feet. The quantity of air which passes in a second is obtained of course by multiplying the area or cross section of the tunnel by this velocity. If that section is half a yard, that is = a quadrangle 2¼ feet by 2, we shall have $23·13 \times 0·5 = 11·565$ cubic yards, $= 312\frac{1}{4}$ cubic feet.

The problem becomes a little more complicated in calculating the velocity of air which has served for combustion, because it has changed its nature, a variable proportion of its oxygen gas of specific gravity 1·111, being converted into carbonic acid gas of specific gravity 1·524.   The quantity of air passed through well constructed furnaces may, in general, be regarded as double of what is rigorously necessary for combustion, and the proportion of carbonic acid generated, therefore, not one half of what it would be were all the oxygen so combined. The increase of weight in such burned air of the temperature of 212°, over that of pure air equally heated, being taken into account in the preceding calculation, will give us about 19 yards or 57 feet per second for the velocity in a chimney 100 yards high incased in steam.

Such are the deductions of theory; but they differ considerably from practical results, in consequence of the friction of the air upon the sides of the chimneys, which varies likewise with its form, length, and quality. The direction and force of the winds also exercise a variable influence upon chimney furnaces differently situated.   In chimneys made of wrought iron, like those of steamboats, the refrigeration is considerable, and causes a diminution of velocity far greater than what occurs in a factory stalk of well built brick work.   In comparing the numbers resulting from the trials made on chimneys of different materials and of different forms, it has been concluded that the obstruction to the draught of the air, or the deduction to be made from the theoretical velocity of efflux, is directly proportional to the length of the chimneys and to the square of the velocity, and inversely to their diameter. With an ordinary wrought-iron pipe, of from 4 inches

to 5 inches diameter, attached to an ordinary stove, burning good charcoal, the difference is prodigious between the velocity calculated by the above theoretical rule, and that observed by means of a stop-watch, and the ascent of a puff of smoke from a little tow, dipped in oil of turpentine thrust quickly into the fire. The chimney being 45 feet high, the temperature of the atmosphere 68° Fahr., the velocity per second was, —

Trials.	By theory.	By experiment.	Mean temperature of chimney.
1	26.4 feet	5 feet	190° Fahr.
2	29·4	5·76	214
3	34·5	6·3	270

To obtain congruity between calculation and experiment, several circumstances must be introduced into our formulæ. In the first place, the theoretical velocity must be multiplied by a factor, which is different according as the chimney is made of bricks, pottery, sheet iron, or cast iron. This factor must be multiplied by the square root of the diameter of the chimney (supposed to be round), divided by its length, increased by

four times its diameter. Thus, for pottery, its expression is $2 \cdot 06 \sqrt{\dfrac{D}{L+D}}$; D being the diameter, and L the length of the chimney.

A pottery chimney, 33 feet high, and 7 inches in diameter, when the excess of its mean temperature above that of the atmosphere was 205° Fahr., had a pressure of hot air equal to 11·7 feet, and a velocity of 7·2 feet per second. By calculating from the last formula, the same number very nearly is obtained. In none of the experiments did the velocity exceed 12 feet per second, when the difference of temperature was more than 410° Fahr.

Every different form of chimney would require a special set of experiments to be made for determining the proper factor to be used.

This troublesome operation may be saved by the judicious application of a delicate differential barometer, such as that invented by Dr. Wollaston; though this instrument does not seem to have been applied by its very ingenious author in measuring the draughts or ventilating powers of furnaces.

If into one leg of this differential syphon water be put, and fine spermaceti oil into the other, we shall have two liquids, which are to each other in density as the numbers 8 and 7. If proof spirit be employed instead of water, we shall then have the relation of very nearly 20 to 19. I have made experiments on furnace draughts with the instrument in each of these states, and find the water and oil syphon to be sufficiently sensible; for the weaker draughts of common fire-places the spirits and oil will be preferable barometric fluids.

To the lateral projecting tube of the instrument, as described by Dr. Wollaston, I found it necessary to attach a stop-cock, in order to cut off the action of the chimney, while placing the syphon, to allow of its being fixed in a proper state of adjustment, with its junction line of the oil and water at the zero of the scale. Since a slight deviation of the legs of the syphon from the perpendicular changes very considerably the line of the level, this adjustment should be made secure by fixing the horizontal pipe tightly into a round hole, bored into the chimney stalk, or drilled through the furnace door. On gently turning the stop-cock, the difference of atmospherical pressure corresponding to the chimney draught, will be immediately indicated by the ascent of the junction line of the liquids in the syphon. This modification of apparatus permits the experiment to be readily rectified by again shutting off the draught, when the air will slowly re-enter the syphon; because the projecting tube of the barometer is thrust into the stop-cock, but not hermetically joined; whereby its junction line is allowed to return to the zero of the scale in the course of a few seconds.

Out of many experiments made with this instrument, I shall content myself with describing a few, very carefully performed at the breweries of Messrs. Trueman, Hanbury, and Buxton, and of Sir H. Meux, Bart., and at the machine factory of Messrs. Braithwaite; in the latter of which I was assisted by Captain Ericsson. In the first trials at the breweries, the end of the stop-cock attached to the differential barometer was lapped round with hemp, and made fast into the circular peep-hole of the furnace door of a wort copper, communicating with two upright parallel chimneys, each 18 inches square and 50 feet high. The fire was burning with fully its average intensity at the time. The adjustment of the level being perfect, the stop-cock orifice was opened, and the junction level of the oil and water rose steadily, and stood at 1¼ inches, corresponding to $\dfrac{1 \cdot 25}{8} = 0 \cdot 156$ of 1 inch of water, or a column of air 10·7 feet high. This difference of pressure indicates a velocity of 26 feet per second. In a second set of experiments, the extremity of the stop-cock was inserted into a hole, bored through the chimney stalk of the boiler of a Boulton and Watt steam-engine of twenty-horse power. The area of this chimney was exactly 18 inches square at the level of the bored hole, and its summit rose 50 feet above it. The fire-grate was about 10 feet below that level. On

opening the stop-cock, the junction line rose 2¼ inches. This experiment was verified by repetition upon different days, with fires burning at their average intensity, and consuming fully 12 lbs. of the best coals hourly for each horse's power, or nearly one ton and a third in twelve hours. If we divide the number 2¼ by 8, the quotient 0·28 will represent the fractional part of 1 inch of water, supported in the syphon by the unbalanced pressure of the atmosphere in the said chimney; which corresponds to 19¼ feet of air, and indicates a velocity in the chimney current of 35 feet per second. The consumption of fuel was much more considerable in the immense grate under the wort copper, than it was under the steam-engine boiler.

In my experiments at Messrs. Braithwaite's factory, the maximum displacement of the junction line was 1 inch, when the differential oil and water barometer was placed in direct communication with a chimney 15 inches square, belonging to a steam boiler, and when the fire was made to burn so fiercely, that on opening the safety-valve of the boiler, the excess of steam beyond the consumption of the engine rushed out with such violence as to fill the whole premises. The pressure of one eighth of an inch of water denotes a velocity of draught of 23·4 feet per second.

In building chimneys, we should be careful to make their area rather too large than too small; because we can readily reduce it to any desired size, by means of a sliding register plate near its bottom, or a damper plate applied to its top, adjustable by wires or chains, passing over pulleys. Wide chimneys are not so liable as narrow ones to have their draught affected by strong winds. In a factory, many furnace flues are often conducted into one vertical chimney stalk, with great economy in the first erection, and increased power of draught in the several fires.

Vast improvements have been made in this country, of late years, in building stalks for steam boilers and chemical furnaces. Instead of constructing an expansive, lofty scaffolding of timber round the chimney, for the bricklayers to stand upon, and to place their materials, pigeon-holes, or recesses, are left at regular intervals, a few feet apart, within the chimney, for receiving the ends of stout wooden bars, which are laid across, so as to form a species of temporary ladder in the interior of the tunnel. By means of these bars, with the aid of ropes and pulleys, everything may be progressively hoisted, for the building of the highest engine or other stalks. An expert bricklayer, with a handy laborer, can in this way raise, in a few weeks, a considerable chimney, 40 feet high, 5 feet 8 inches square outside, 2 feet 8 inches inside at the base, 28 inches outside, and 20 inches inside at the top. To facilitate the erection, and at the same time increase the solidity of an insulated stalk of this kind, it is built with three or more successive plinths, or recedures, as shown in *fig.* 281. It is necessary to make such chimneys thick and substantial near the base, in order that they may sustain the first violence of the fire, and prevent the sudden dissipation of the heat. When many flues are conducted into one chimney stalk, the area of the latter should be nearly equal to the sum of the areas of the former, or at least of as many of them as shall be going simultaneously. When the products of combustion from any furnace must be conducted downwards, in order to enter near the bottom of the main stalk, they will not flow off until the lowest part of the channel be heated by burning some wood shavings or straw in it, whereby the air syphon is set agoing. Immediately after kindling this transient fire at that spot, the orifice must be shut by which it was introduced; otherwise the draught of the furnace would be seriously impeded. But this precaution is seldom necessary in great factories, where a certain degree of heat is always maintained in the flues, or, at least, should be preserved, by shutting the damper plate of each separate flue, whenever its own furnace ceases to act. Such chimneys are finished at top with a coping of stone-slabs, to secure their brickwork against the infiltration of rains, and they should be furnished with metallic conducting rods, to protect them from explosions of lightning.

When small domestic stoves are used, with very slow combustion, as has been recently proposed, upon the score of a misjudged economy, there is great danger of the inmates being suffocated or asphyxied, by the regurgitation of the noxious burned air. The smoke doctors who recommend such a vicious plan, from their ignorance of chemical science, are not aware that the carbonic acid gas, of coke or coal, must be heated 250° F. above the atmospheric air, to acquire the same low specific gravity with it. In other words, unless so rarefied by heat, that gaseous poison will descend through the orifice of the ash-pit, and be replaced by the lighter air of the apartment. Drs. Priestley and Dalton have long ago shown the co-existence of these two-fold crossing currents of air even through the substance of stone-ware tubes. True economy of heat, and salubrity alike require vivid combustion of the fuel, with a somewhat brisk draught inside of the chimney, and a corresponding abstraction of air from the apartment. Wholesome continuous ventilation, under the ordinary circumstances of dwelling houses, cannot be secured in any other way. Were these mephitic stoves, which have been of late so ridiculously puffed in the public prints, generally introduced, the faculty would

ed to be immediately quadrupled to supply the demand for medical advice; for head-hes, sickness, nervous ailments, and apoplexy, would become the constant inmates of ery inhabited mansion. The phenomena of the grotto of Pausilippo might then be ily realized at home, among those who ventured to recline upon sofas in such carbo-ted apartments; only instead of a puppy being suffocated *pro tempore*, human beings uld be sacrificed, to save two-penny worth of fuel *per diem*.

282   285   281

283

284   286
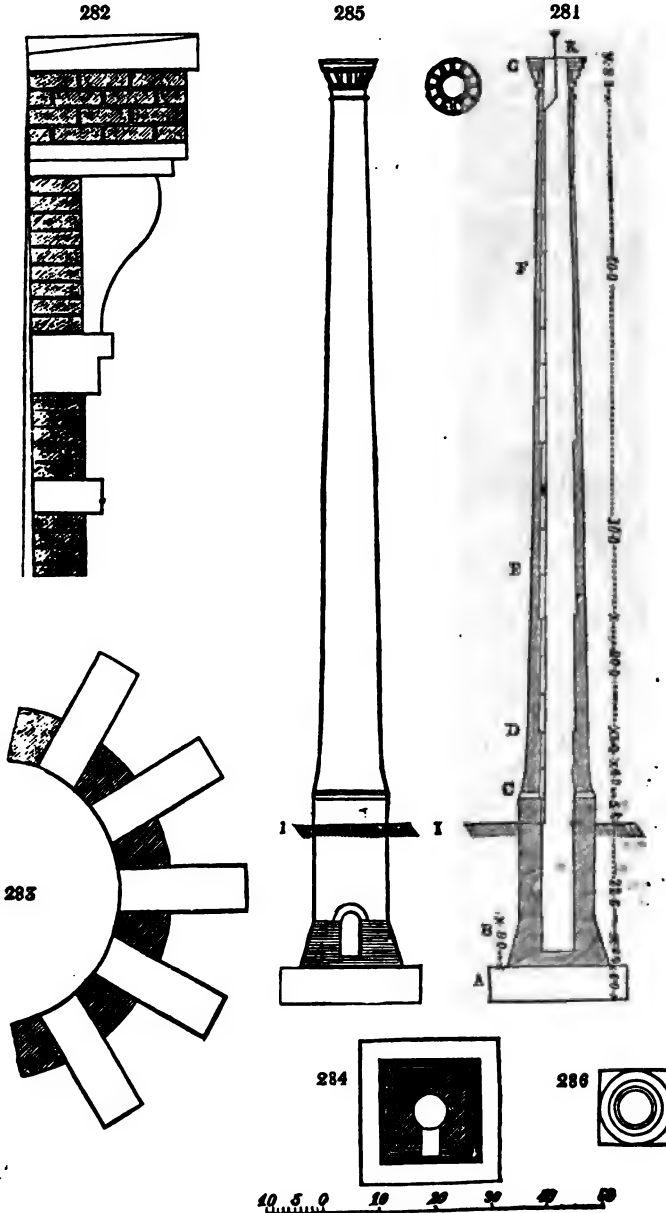
The figures upon the preceding page represent one of the two chimneys recently erected at the Camden Town station, for the steam boilers of the two engines of 60 horse-power each, belonging to the London and Birmingham Railway Company. These engines draw their train of carriages up the inclined plane of Hampstead Hill. The chimneys were designed by Robert Stephenson, Esq., engineer to the Company, executed by William Cubitt, Esq., of Gray's Inn Road,—and do equal honor to both gentlemen, being probably the most elegant and substantial specimens of this style of architecture in the world.   In the section, *fig.* 281,

A represents a bed of *concrete,* 6 feet thick, and 24 feet square.

B, brick footings set in cement; the lower course 19 feet square.

C, Bramley-fall stone base, with a chain of wrought iron let into it.

D, a portion, 15 feet high, curved to a radius of 113 feet, built entirely of Malm paviors, (a peculiarly good kind of bricks.)

E, shaft built of Malm paviors in mortar.

F, ditto, built from the inside, without exterior scaffolding.

G, the cap ornamented (as shown in the plan alongside) with Portland stone, the dressings being tied together with copper cramps and an iron bond.

Fig. 282 represents the mouldings of the top, upon an enlarged scale.

Fig. 283, a plan of the foundation, ditto.

Fig. 284, ditto, at the level of the entrance of the flue, as seen in

Fig. 285, the elevation of the chimney.

Fig. 286, plan at the ground level I, in *figs.* 281 and 285.

K, *fig.* 281, the lightning conducting rod.

CHINTS is a peculiar style of fast-printed calico, in which figures of at least five different colors are impressed upon a white or light colored ground.

CHLORATE OF POTASH, commonly called oxymuriate of potash.   This interesting saline compound has become the object of a pretty extensive manufacture, in consequence of its application to make matches for procuring instantaneous light, and a detonating powder for fire-arms.   It may be prepared both in the humid and dry way.

Having made a strong solution of purified potash, or carbonate of potash, with from two to three parts of water, we pass through it in a Woulfe's apparatus a current of chlorine gas, till it ceases to absorb any more.   Chloride of potash and chloride of potassium alone are formed as long as there is an excess of alkali in the solution; but afterwards, in the further reaction of the materials, the chloride passes into the state of a chlorate, and, as such, precipitates from the solution.   During the first half of the operation, that is, till the potash be about one half saturated with chlorine, as indicated by litmus paper ceasing to be darkened and beginning to be blanched, only the chloride of potassium or muriate of potash falls.   The process should be interrupted at this point in order to remove the salt, to wash it, to add the washings to the liquor, and then to transmit the gas freely through the solution.   As the operation advances, less muriate of potash is formed, and at length nothing but the pure chlorate is separated in crystals.   When finally the bubbles of gas pass through without being sensibly absorbed, the process is known to be completed; the liquid may then be allowed to settle, and be poured off from the crystals of chlorate of potash, which are purified from the muriate by dissolving them in three times their weight of boiling water, and filtering the solution while hot.   On its cooling, the chlorate will separate in pearly-looking crystalline plates.   It may be rendered quite pure by a second crystallization, in which state it does not affect solution of nitrate of silver.

The above potash ley usually gets a reddish tint in the course of the process in consequence of a little manganesic acid coming over with the chlorine, but it gradually loses this color as the saturation becomes complete, when the solution turns yellow.   The tubes for conveying the gas should be of large diameter, if they be plunged into the saline solution, because the crystallization which takes place in it is apt to choke them up.   This inconvenience may however be obviated by attaching to the end of the glass tube, a tube of caoutchouc terminated in a small glass funnel, or simply the neck of a caoutchouc bottle with a part of its body, whose width will not be readily closed with a saline crust.   The residuary lixivium may be used against another operation, or it may be evaporated down to half its bulk and set aside to crystallize, whereby some more chlorate will be obtained, mixed indeed with muriate and carbonate, from which however it may be separated by a second crystallization.   In general the pure chlorate obtained does not exceed one tenth the weight of the potash employed; because in thus treating potash with chlorine, five sixths of it are converted into muriate of potash and only one sixth into chlorate, and a part of the latter adheres to the muriate, or is lost in the mother waters of the crystallizations.

The chlorate of potash may be more conveniently manufactured, like that of lime, in the dry way.   St. Romer patented at Vienna the following method for that purpose in 1821 : — Ten pounds of crystallized peroxyde of manganese are to be finely pulverized, mixed with ten pounds of plumbago, and thirty pounds of common salt, and put into the

iden retort represented in *fig.* 287, p. 293. From the middle of the helmet-shaped l of this vessel, a lead tube, two feet long, and two inches wide, conducts to the receiver, hich is a square earthen pan, hard glazed both within and without, of the same capacity ith the retort. The end of the tube must be made fast to a frame at the height of six ches above the bottom of the receiver. Upon its inner sides, four inches apart, brackets e to be fixed for supporting a series of laths or shelves of white wood, on which a num- r of little paper or pasteboard boxes are to be laid. In these boxes ten pounds of the rest carbonate of potash, prepared from tartar, are to be spread. The receiver must w be covered with a lid made tight by a water lute. Twenty pounds of concentrated lphuric acid previously diluted with sixteen pounds of water, and then cooled, are to poured upon the mixed materials in the retort, the lid immediately secured, with the be adjusted in the receiver. The whole must be allowed to operate spontaneously with- t heat for twelve hours. At the end of this time the retort is to be surrounded with a ater bath and steadily heated during twelve hours, and then left to cool for six hours. he apparatus must now be opened, the cakes of chlorate of potash removed, and freed om muriate by solution and crystallization.

M. Liebig proposes the following process for obtaining chlorate of potash :—

Heat chloride of lime in water till it ceases to destroy vegetable colors. In this case a ixture of chloride of calcium and chlorate of potash is obtained. This is to be dissolved hot water, and to the solution concentrated by evaporation, chloride of potassium is to added, and then suffered to cool. After cooling, a quantity of crystals of chlorate of tash is obtained, which are to be redissolved and crystallized again to purify them. M. iebig considers that this will be a cheap process for obtaining chlorate of potash. From ounces of chloride of lime, of so bad a quality that it left 65 per cent. of insoluble atter, he obtained an ounce of chlorate of potash.

The only difficulty to overcome in this process is, from the chloride of lime not being easily decomposed by heat as is generally supposed ; a solution of it may be kept boil- g for an hour without losing its bleaching power. The best method is to form a thin ste with chloride of lime and water, and then to evaporate it to dryness. If it be re- ired to prepare it by passing chlorine into cream of lime, it is advantageous to keep it ry hot.

The chlorate of potash which separates from the solution by crystallization, has not e form of scales which it usually possesses, but is prismatic : whether this is occasioned y some admixture has not been ascertained ; but on re-crystallizing, it is obtained in the snal form.

The solution ought not merely to be left to cool, in order to procure crystals, for the rystallization is far from being terminated even after complete cooling ; crystals continue be deposited for 3 or 4 days.

The following modification of the process for making chlorate of potash is that of M. ée. A solution of chloride of lime, marking 18° or 20° Baumé, is to be set upon the fire n a lead or cast iron pot, and when it begins to get hot, there is to be dissolved in it a uantity of chloride of potassium sufficient to raise the hydrometer 3 or 4 degrees. It nust be then concentrated as quickly as possible till it marks 30° or 31°, taking care that t does not boil over by the sudden extrication of oxygen. The concentrated liquor is set side to crystallize in a cool place ; where a deposite of chlorate of potash forms, mixed rith chloride of potassium. The mother waters being evaporated to the density of 36°, fford another crop of crystals, after which they may be thrown away.

The salts obtained at the first crystallization are to be re-dissolved, and the solution being brought to 15° or 16° is to be filtered, when it will afford upon cooling pure chlo- rate of potash.

Chlorate or oxymuriate of potash has a cooling, somewhat unpleasant and nitrous taste. It does not bleach. At 60° F. 100 parts of water dissolve six parts of it, and at its boiling point or 220°, sixty parts. When heated to dull ignition in a glass retort, it gives out 39·15 per cent. of its weight of oxygen, and becomes thereby chloride of potassium. When strongly triturated in a mortar it crackles, throws out sparks, and be- comes luminous. It deflagrates upon red-hot cinders like nitre : when triturated along with sulphur, or phosphorus, it detonates with great violence, not without danger to the hands of the operator, if they be not protected by a thick glove. Similar detonations may be produced with cinnibar or vermilion, sulphuret of potassium, sugar, volatile oils, &c., but they can be effected only by the smart blow of a heated hammer and anvil. A mixture of sugar or starch with chlorate of potash is readily inflamed by a drop of sul- phuric acid, and this experiment is the basis of the preparation of the oxygenated matches, as they have been commonly called. The following formula forms a good paste for tipping the said matches, made of narrow slips of either wood or card. Thirty parts of the chlorate in fine powder are to be mixed gently with a spatula upon paper with ten parts of flowers of sulphur well levigated, eight of sugar, five of gum arabic, and enough of vermilion to give the whole a rose tint. We begin by mixing tenderly together

9

the sugar, the gum, and the salt previously pulverized; we then add as much water as shall reduce the mixture to a thin paste, and lastly introduce the sulphur; after which all must be well incorporated The points of the matches, either previously tipped with sulphur or not, are to be dipped in that paste, so as to get coated with a little of it, and are lastly laid in a warm place till they become thoroughly dry. To kindle one of them, it must be touched with strong sulphuric acid, which for this purpose is usually kept in a small well-stoppered vial, and thickened with amianthus. Aspen is reckoned the best wood for matches.

Of late years a detonating priming for fire-arms has been much used with the percussion locks. The simplest formula for making it is to take ten parts of gunpowder, to lixiviate it with water, and to mix the residuum, while moist, with five parts and a quarter of chlorate of potash, reduced to an extremely fine powder. The paste may be made pretty thin, for the salt is sparingly soluble in the cold water, and it mixes best when tolerably fluid. This powder when dry is dangerous to handle, being very apt to explode. But this danger is guarded against by letting fall a drop of the paste into each copper percussion cap, and leaving it to dry there. In the detonation of this powder, besides muriate of potash, there are generated, a little sulphate of potash and chlorine gas, which rust the metal very fast. For which reason fulminate of mercury is now preferred by many sportsmen as a detonating powder. See Fulminate.

CHLORATES, compounds of chloric acid with the salifiable bases. The only acid belonging to this class of any manufacturing importance is the following:

CHLORIC ACID; the acid constituent of the preceding salt; it consists of one equivalent prime of chlorine $= 35 \cdot 176$, $+ 5$ of oxygen, $= 40 \cdot 065$; of which the sum $75 \cdot 535$ is the prime equivalent of the acid.

CHLORINE; the most energetic of the undecompounded bodies, or chemical elements as they are usually called, exists, under ordinary circumstances, as a greenish yellow gas, but, when exposed to a pressure of 4 atmospheres, it becomes a yellow transparent liquid. In the first state, its density compared to air, reckoned $1 \cdot 000$, is $2 \cdot 47$; in the second, its density compared to water, $1 \cdot 000$, is $1 \cdot 33$. No degree of cold hitherto tried, has liquefied the gas when dry. It is obtained by putting into a glass retort a mixture of 3 parts of common salt, with 2 parts of peroxyde of manganese, and pouring upon it 2 parts of sulphuric acid diluted with its own weight of water; or, more conveniently, by pouring moderately strong muriatic acid upon peroxyde of manganese in a retort; and in either case applying the gentle heat of a spirit lamp or a water bath, while the beak of the retort is plunged under brine upon the shelf of the pneumatic trough. The gas issues, and may be received in the usual way into inverted glass jars, or vials; but the first which comes over, being mixed with the air of the retort, must be rejected. It has a peculiar smell, and irritates the nostrils most violently when inhaled, as also the windpipe and lungs. It is eminently noxious to animal life, and, if breathed in its undiluted state, would prove instantly fatal. It supports the combustion of many bodies, and indeed spontaneously burns several without their being previously kindled. The resulting combinations are called chlorides, and act most important parts in many manufacturing processes.

Water absorbs, at the ordinary temperature of the atmosphere, about double its volume of chlorine, and acquires the color, smell, and taste of the gas, as well as its power of destroying or bleaching vegetable colors. When this aqueous chlorine is cooled to 36° F. dark yellow crystalline plates appear in it of the hydrate of chlorine, which are composed in 100 parts of $27 \cdot 7$ chlorine, and $72 \cdot 3$ water. If these crystals be heated to about 45° they liquefy, and the gas flies off.

Chlorine has a powerful affinity for hydrogen, not only combining with it rapidly in the gaseous, but seizing it in many of its liquid and solid combinations, as in volatile oils, which it inflames, and in yellow wax, cotton, and flax, which it whitens. The compound of chlorine and hydrogen gases is muriatic acid gas. Manganese, when mixed with liquid muriatic acid, as in the above process, abstracts the hydrogen, and lets the chlorine gas go free. When chlorine is passed into water, it decomposes some of it, seizes its hydrogen to form a little muriatic acid, and enables its oxygen to unite either with the chlorine, into chlorous acid, or with the remaining water, and to constitute oxygenated water. Hence, aqueous chlorine, exposed to the sunbeam, continually evolves oxygen, and ere long becomes muriatic acid.

This watery compound acts in a powerful way upon colored vegetable fibres, extracting their hydrogen or coloring element by the twofold affinities of the chlorine and oxygen for it.

Hence chlorine, as a bleaching agent, requires to be tempered by the quiescent affinity of some alkaline base, potash or lime. Malaria, or morbific and putrescent miasmata, consist chiefly of hydrogenous matter as their basis, and are best counteracted by chlorine, where it can be conveniently applied.

Chlorides of Potash, Soda, and Lime.—These are the most important preparations

ugh which chlorine exercises its peculiar powers upon the objects of manufactures. :n a weak solution of caustic potash or soda is saturated with chlorine, it affords a ching liquor which is still used by some blenchers and calico-printers for their most :ate processes; but the price of the alkalis has led to the disuse of these chlorides as neral means, and has occasioned an extensive employment of chloride of lime. Upon manufacture of this interesting compound I made an elaborate series of experiments, ral years ago, and published the results in the 13th volume of Brande's Journal for il, 1822. I have no reason to suppose, from any thing that has been published since, the processes there described have been essentially improved, or that any errors, er theoretical or practical, of any moment, exist in that memoir. I shall therefore present my readers with a brief abstract of it, and then make such observations as equent inquiries suggest.

the researches which I made, at many different times, upon the nature of the chlo- of lime, I generally sought to combine the information flowing from both synthesis analysis; that is, I first converted a known portion of hydrate of lime into bleach- powder, and then subjected this chloride to analysis.

wo hundred grains of the atomic proto-hydrate of pure lime were put into a glass e, which was kept cold by immersion in a body of water at 50°. A stream of rine, after being washed in water of the same temperature in another glass globe, nected to the former by a long narrow glass tube, was passed over the calcareous rate. The globe with the lime was detached from the rest of the apparatus from : to time, that the process might be suspended as soon as the augmentation of weight ;ed. This happened when the 200 grains of hydrate, containing 151·9 of lime, had orbed 130 grains of chlorine. By one analytical experiment, it was found that dilute iatic acid expelled from 50 grains of the chloride, 20 grains of chlorine, or 40 per t.; and by another, from 40 grains, 16·25 of gas, which is 40·6 per cent. From the duum of the first 39·7 grains of carbonate of lime were obtained by carbonate of nonia; from that of the second, 36·6 of ignited muriate of lime. The whole results therefore as follows :—

	Synthesis.	1st Analysis.	2d Analysis.	Mean.
Chlorine - -	39·39	40·00	40·62	40·31
Lime - - - -	46·00	44·74	46·07	45·40
Water - - -	14·60	15·26	13·31	14·28
	100·00	100·00	100·00	100·00

though the heat generated by the action of the dilute acid had carried off in the ana- cal experiments a small portion of moisture with the chlorine, yet their accordance h the synthetic experiment is sufficiently good to confirm the general results. The ve powder appears to have been a pure chloride, without any mixture of muriate. it exhibits no atomic constitution in its proportions.

o 200 grains of that hydrate of lime 30 grains of water being added, the powder was jected to a stream of chlorine in the above way, till saturation took place. Its in- se of weight was 150 grains.

t ought to be remarked, that in this and the preceding experiment there was no appre- le pneumatic pressure employed to aid the condensation of the chlorine. In the last e, we see that the addition of 30 grains of water has enabled the lime to absorb 20 ins more of chlorine, being altogether a quantity of gas nearly equal to that of the dry e. Thus, an atom of lime seems associated with $\frac{7}{9}$ of an atom of chlorine. Analysis muriatic acid confirmed this composition. It gave

$$\text{Chlorine - - } 39\cdot5 = 51\cdot8 \text{ cubic inches.}$$
$$\text{Lime - - - } 39\cdot9$$
$$\text{Water - - - } 20\cdot6$$
$$\overline{100\cdot0}$$

great variety of apparatus has been at different times contrived for favoring the bination of chlorine with the slaked lime for the purposes of commerce. One of most ingenious forms is that of a cylinder, or barrel, furnished with narrow wooden lves within, and suspended on a hollow axis by which the chlorine was admitted, and nd which the barrel was made to revolve. By this mode of agitation, the lime-dust, ag exposed on the most extensive surface, was speedily impregnated with the gas to requisite degree. Such a mechanism I saw at MM. Oberkampf and Widmer's cele- ted *fabrique de toiles peintes*, at Jouy, in 1816. But this is a costly refinement, in- aissible on the largest scale of British manufacture. The simplest, and, in my aion, the best construction for subjecting lime-powder to chlorine, is a large chamber

8 or 9 feet high, built of silicious sandstone, having the joints of the masonry secured with a cement composed of pitch, resin, and dry gypsum in equal parts. A door is fitted into it at one end, which can be made air-tight by strips of cloth and clay-lute. A window on each side enables the operator to judge how the impregnation goes on by the color of the air, and also gives light for making the arrangements within at the commencement of the process. As water lutes are incomparably superior to all others, where the pneumatic pressure is small, I would recommend a large valve or door on this principle to be made in the roof, and two tunnels of considerable width at the bottom of each side wall. The three covers could be simultaneously lifted off by cords passing over a pulley, without the necessity of the workman approaching the deleterious gas, when the apartment is to be opened. A great number of wooden shelves, or rather trays, 8 or 10 feet long, 2 feet broad, and 1 inch deep, are provided to receive the riddled slaked lime, containing generally about 2 atoms of lime to 3 of water. These shelves are piled one over another in the chamber, to the height of 5 or 6 feet, cross bars below each keeping them about an inch asunder, that the gas may have free room to circulate over the surface of the calcareous hydrate.

The alembics for generating the chlorine, which are usually nearly spherical, are in some cases made entirely of lead, in others of two hemispheres, joined together in the middle, the upper hemisphere being lead, the under one cast-iron. The first kind of alembic is enclosed, for two thirds from its bottom, in a leaden or iron case, the interval of two inches between the two being destined to receive steam from an adjoining boiler. Those which consist below of cast-iron have their bottom directly exposed to a very gentle fire; round the outer edge of the iron hemisphere a groove is cast, into which the under edge of the leaden hemisphere fits, the joint being rendered air-tight by Roman or patent cement. In this leaden dome there are four apertures, each secured by a water-lute. The first opening is about 10 or 12 inches square, and is shut with a leaden valve, with incurvated edges, that fit into the water channel at the margin of the hole. It is destined for the admission of a workman to rectify any derangement in the apparatus of rotation, or to detach hard concretions of salt from the bottom.

The second aperture is in the centre of the top. Here a tube of lead is fixed, which descends nearly to the bottom, and down through which the vertical axis passes. To its lower end the cross bars of iron, or of wood, sheathed with lead, are attached, by whose revolution the materials receive the proper agitation for mixing the dense manganese with the sulphuric acid and salt. The motion is communicated either by the hand of a workman applied from time to time to a winch at top, or it is given by connecting the axis with wheel work, impelled by a stream of water or a steam-engine. The third opening admits the syphon-formed funnel, through which the sulphuric acid is introduced; and the fourth is the orifice of the eduction-pipe.

Manufacturers differ much from each other in the proportion of their materials for generating chlorine. In general, 10 cwt. of salt are mixed with from 10 to 14 cwt. of manganese, to which mixture, after its introduction into the alembic, from 12 to 14 cwt. of sulphuric acid are added in successive portions. That quantity of oil of vitriol must, however, be previously diluted with water, till its specific gravity becomes about 1·6. But, indeed, this dilution is seldom actually made, for the manufacturer of bleaching-powder almost always prepares his own sulphuric acid for the purpose, and therefore carries its concentration no higher in the leaden boilers than the density of 1·65, which from my table of sulphuric acid, indicates ¼ of its weight of water, and therefore ½ more of such acid must be used.

The fourth aperture, I have said, admits the eduction pipe. This pipe is afterwards conveyed into a leaden chest or cylinder, in which all the other eduction pipes also terminate. They are connected with it simply by water-lutes, having a hydrostatic pressure of 2 or 3 inches. In this general *diversorium* the chlorine is washed from adhering muriatic acid, by passing through a little water, in which each tube is immersed, and from this the gas is let off by a pretty large leaden tube, into the combination room. It usually enters in the top of the ceiling, whence it diffuses its heavy gas equally round.

Four days are required, at the ordinary rate of working, for making good marketable bleaching-powder. A more rapid formation would merely endanger an elevation of temperature, productive of muriate of lime, at the expense of the bleaching quality. But skilful manufacturers use here an alternating process. They pile up, first of all, the wooden trays only in alternate shelves in each column. At the end of two days the distillation is intermitted, and the chamber is laid open. After two hours the workman enters, to introduce the alternate trays covered with fresh hydrate of lime, and at the same time rakes up thoroughly the half-formed chloride in the others. The door is then secured, and the chamber, after being filled for two days more with chlorine, is again opened, to allow the first set of trays to be removed, and to be replaced by others, containing fresh hydrate, as before. Thus the process is conducted in regular alternation;

thus, to my knowledge, very superior bleaching-powder is manufactured, and thus the chlorine may be suffered to enter in a pretty uniform stream. But for this judicious plan, as the hydrate advances in impregnation, its faculty of absorption becoming diminished, it would be requisite to diminish proportionately the evolution of chlorine, or to allow the excess to escape, to the great loss of the proprietor, and, what is of more consequence, to the great detriment of the health of the workmen.

The manufacturer generally reckons on obtaining from one ton of rock-salt, employed as above, a ton and a half of good bleaching-powder. But the following analysis of the operation will show that he ought to obtain two tons.

When a mixture of sulphuric acid, common salt, and black oxyde of manganese are the ingredients used, as by the manufacturer of bleaching-powder, the absolute proportions are, upon the oxygen scale of equivalents: —

1 atom muriate of soda	-	-	7·5	29·70	100·0
1 atom peroxyde of manganese	-	5·5	21·78	73·3
2 atoms oil of vitriol 1·846	-	-	12·25	48·52	163·3
			25.25	100.00	

And the products ought to be ; —

Chlorine disengaged	-	- 1 atom.	4·5	17·82
Sulphate of soda	-	- 1 —	9·0	35·64
Proto-sulphate of manganese	- 1 —	9·5	37·62
Water	-	-	- 2 —	2·25	8·92
			25·25	100·00

These proportions are, however, very different from those employed by many, nay, I believe by all manufacturers; and they ought to be so, on account of the impurity of their oxyde of manganese. Yet making allowance for this, I am afraid that many of them commit great errors in the relative quantities of their materials.

From the preceding computation, it is evident that 1 ton of salt with 1 ton of the above native oxyde of manganese properly treated, would yield 0·59 of a ton of chlorine, which would impregnate 1·41 tons of slaked lime, producing 2 tons of bleaching-powder, stronger than the average of the commercial specimens; or allowing for a little loss, which is unavoidable, would afford 2 tons of ordinary powder, with a little more slaked lime.

Fig. 287 represents a retort of lead, well adapted to the evolution of chlorine from the
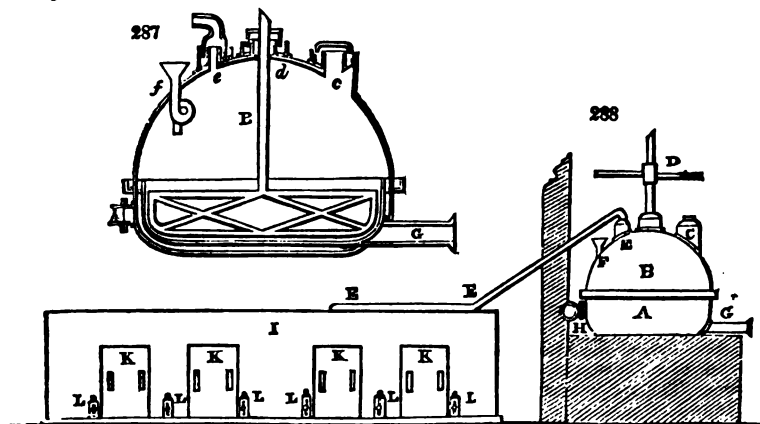
mixture of salt, manganese, and sulphuric acid, or from manganese and muriatic acid. The interior vessel is cast in lead, and it has round its bottom part a cast-iron steam cast. The salt and manganese are introduced by the aperture c, and the sulphuric acid by the syphon funnel F. The contact of these three substances is continually renewed by the agitator or stirrer B, which consists of wrought or cast iron sheathed with lead. *e* is the gas discharge pipe. The residuums are drawn off by the bottom discharge pipe G. The heating case receives its steam by the pipe *h*.

The chlorine gas, *fig.* 288, is conveyed from the retort B into the chamber I, by the tube I I I. This chamber is divided into four compartments, to receive the gas disengaged from four retorts, like the above. The bottom of it is covered with a stratum three or four inches thick of quicklime, newly slaked and sifted, which is stirred about from

time to time, by the rakes L L L L. When the saturation is sufficient, the chloride of lime is taken out by the doors K K K K. The size of this apparatus allows 2 cwt. of manganese, and its equivalent quantity of salt and sulphuric acid, or of muriatic acid, to be introduced at once into the retort. D is the handle of the agitator.

The same form of retort will suit perfectly well to prepare chlorine for making liquid chloride of lime, which is preferred by many bleachers and calico-printers who have conveniences for preparing it themselves. The most concentrated solutions of the dry chloride of lime do not mark more than 6° B. (sp. grav. 1·04), and discolor only 50 volumes of Gay Lussac's solution of indigo, whilst the chloride made in the humid way marks from 8° to 9° B. (about 1·060), and discolors 80 volumes of the same solution.

In the chloride of lime apparatus, most generally used by the skilful calico-printers of Mulhausen, the mixture of muriatic acid and manganese is put into glass globes, with long necks, heated upon a sand-bath. The chlorine is conveyed by glass tubes into a cylindrical stone cistern, containing milk of lime. The furnace of the sand baths is made of cast iron, and has brick partitions, to give each retort its own fire. The smoke of all these fires goes off by a flue into sheet iron pipes. The cistern is made of siliceous sand-stone. Its cover is of wood, coated with a resinous cement; and it fits at its edges into grooves cut in the stone. A wheel serves to agitate the liquid continually; its paddles being kept at two inches distance from the sides of the cistern. The milk of lime is introduced by a funnel, and the chloride is drawn off by a discharge pipe. I think the lead retort and agitator used in this country greatly preferable to the experimental laboratory plan described above. In all such apparatus we should avoid giving any pressure to the tubes or vessels, and should not therefore dip the extremities of the gas pipes beneath the surface of the liquid, but rather facilitate the combination of the chlorine and the lime, by enlarging the surfaces of contact and by agitating. Intermediate vessels containing water, or the chemical cascade of M. Clement, are very useful for absorbing any muriatic acid which may be disengaged along with the chlorine, and thereby preventing the needless formation of muriate of lime in the chambers or cisterns of impregnation.

When the solution of the chloride of lime is mixed with hydrate of lime, it bears, without decomposing, a pretty high temperature, provided it be not too long continued; it may even, in certain cases, be raised to near the boiling point without suffering a marked loss of its discoloring power; but when the chloride is deprived of that excess of lime, it is decomposed in a short time, even at a heat of 110° F.

When chlorine is admitted to milk of lime, it infallibly produces some muriate of lime; but the quantity is kept at a *minimum* by constantly presenting an excess of lime to the gas with the agitator, and by keeping the temperature as low as possible. Hence the influx of gas should not be so rapid as to generate much heat. An automatic agitator, moved by steam or water power, is therefore much better than one driven by the hand of the operator, who is apt to intermit his labors. If the liquor becomes hot at the end of the process, it should be immediately drawn off into large stone bottles, and cooled. The rose-color, which sometimes supervenes, is due to a minute quantity of manganese. The strongest liquid chloride of lime that can be prepared will not discolor more than 80 times its volume of Gay Lussac's indigo test.

On acting upon cotton cloth with a concentrated solution of chloride of lime, at from 110° to 120° F., pure carbonic acid gas is disengaged, and the texture of the cloth is injured. Here the hydrogen of the water and the cotton being seized by the chlorine, the liberated oxygen combines with the carbon to form carbonic acid. In the discharge troughs where printed calicoes are passed through strong solutions of chloride of lime, stalactitic crusts of carbonate of lime come to be formed in this way.

The *chlorometre* of Gay Lussac consists of a test solution of indigo and a graduated tube. One part of the best indigo, passed through a silk sieve, is to be dissolved in nine parts of concentrated sulphuric acid, by the aid of a water-bath heat applied for six hours. The sulphate of indigo is now to be diffused through such a body of water that one volume of chlorine gas shall discolor exactly ten times its volume of this dilute solution. The test liquor should be protected from the agency of light.

Mr. Crum, of Thorniebank, near Glasgow, has lately modified Dr. Dalton's copperas test for chloride of lime, and made it convenient to the practical man. The doctor justly considered that the more chlorine any bleaching powder contains, the more of the green sulphate of iron will it convert into the red sulphate, so that we have only to add successive portions of the chloride to a given weight of the dissolved copperas, and note the point at which all the iron gets peroxydized. See BLEACHING.

Besides the method of analysis already quoted from my memoir on the manufacture of the chloride of lime, another occurred to me long ago, which I often practised as an easy and expeditious test. Chlorine decomposes ammonia. If therefore water of ammonia, faintly tinged with litmus, be added slowly to a solution of a given weight of

chloride of lime, the color will continue to disappear till the chlorine be all neutralized by the reaction of the hydrogen of the ammonia. The quantity of liquid ammonia of a certain strength requisite to neutralize in this way a certain volume, say one cubic inch, or a thousand grain measures of chlorine gas, may be assumed as the standard of such a chlorometer. As chlorine or chloride of lime, when mixed with water of ammonia, causes the disengagement of azote, the quantity of this gas evolved may also be made the foundation of an accurate and convenient chlorometer. The two substances should be mixed over mercury, in a graduated syphon tube. The shut end A and the open end B are both graduated to one scale; for example, to hundredths of a cubic inch, or to grain or 10 grain measures. The tube is to be filled with mercury, and then 10 measures of it are to be displaced at the open end, by inserting a wooden plug. This space being filled with the solution of chloride of lime, is to be turned up into the shut end by covering the open end with the finger, and inverting the tube; a few drops of water may be sent through to wash the mercury. The ammonia being now let up, will cause a reaction, and evolve a quantity of azote, equivalent to the chlorine present. The action may be quickened by holding the sealed end of the tube obliquely over a lamp heat. The mercury is protected from the chlorine by the ammonia; and should any notion be entertained of such an action, the ammonia may be let up first. I have made innumerable researches over mercury with a detached apparatus of that kind, which combines precision with rapidity of result. It was by a similar mercurial syphon that I analyzed the carbonates, as described in the first edition of my Dictionary of Chemistry, twenty-one years ago.

M. Gay Lussac takes, as the basis of his indigo chlorometer, the fact, that one pound of pure crystallized peroxyde of manganese is capable of affording, with muriatic acid, 0·7964 parts of a pound of chlorine; or one kilogramme yields 251¼ litres; that is, one pound yields 251¼ pound measures. Hence 3·98 grammes of that manganese are capable of affording 1000 gramme measures, or 1 litre of chlorine; or, in round numbers, 4 grains will yield 1000 grain measures. This quantity of gas, being received into that volume of milk of lime, constitutes therefore Gay Lussac's primary standard. The small retort in which the manganese and muriatic acid are put, ought to be heated to ebullition, to discharge every particle of chlorine. To prevent the manganese, in this experiment, from sticking to the bottom in a cake, it has been proposed to mix it previously with a little plumbago. See CHLOROMETRY.

For preparing the chlorides of potash and soda, the same apparatus may be employed as for the liquid chloride of lime. The alkaline solutions should be weak, containing not more than a pound to the gallon of water. Potash liquor saturated with chlorine, is much employed at Paris for whitening linen, under the name of the water of Javelle, the place where it was first made as a manufacture. One hundred parts of chlorine are said to saturate 133 parts of pure potash, and 195 of the carbonate; but the latter should not be used for preparing the bleaching fluid, as the carbonic acid resists the combination of the chlorine. A chloride of carbonate of soda has been lately recommended as a disinfecting substance against contagious miasmata or *fomites.* One hundred parts of chlorine will saturate 150 of the dry carbonate, and 405 of the crystallized. M. Payen prepares this medicinal chloride by adding 138 parts of carbonate of soda to a liquid, consisting of water 1800, chloride of lime 100, at 98° of strength, by Gay Lussac's standard. The chloride of lime is to be dissolved, and the sediment well washed; the carbonate of soda, dissolved by heat, is to be poured into the solution, the precipitate allowed to subside, the clear fluid decanted, and the solid matter washed upon a filter. The collected solutions are neutral chloride of soda. Sixty-two parts of the carbonate of soda are then to be dissolved in the remainder of the water, and added to the preparation; the whole being thus filtered, a limpid liquor is obtained, indicating 5° by the hydrometer of Baumé.

The chloride of magnesia was long ago proposed by Sir H. Davy for bleaching linen, as being preferable to chloride of lime, because the resulting muriate of magnesia was not injurious to the fibre of cloth, as muriate of lime may be, under certain circumstances. I prepared a quantity of chloride of magnesia, by exposing a hydrate of that earth in the chlorine chamber of a large manufactory of chloride of lime at Glasgow, and obtained a compound possessed of considerable discoloring powers; but I found that the chlorine was so feebly saturated by the base, that it destroyed the colors of fast-dyed calicoes as readily as chlorine gas or chlorine water did, and was therefore dangerous for common bleaching, and destructive in clearing the grounds of printed goods, which is one of the most valuable applications of the calcareous and alkaline chlorides. The occasion of my making these experiments was the importation of a considerable quantity of magnesite, or native atomic carbonate of magnesia, from the district of Madras, by an enterprising friend of mine   Encouraged by the encomiums bestowed on the chloride of magnesia by many chemical writers, he

expected to have benefited both the country and himself, by bringing home the earthy base of that compound, at a moderate price; but was disappointed, to his cost.

Dr. Thomson is of opinion that the bleaching compound of lime and chlorine is not a chloride of lime, but a combination of chlorous acid with lime and of chlorine with calcium; consisting in its most concentrated state of

$$
\begin{array}{ll}
\text{3 atoms of chloride of calcium} & = 21 \\
\text{1 atom of chlorite of lime} \quad - & = 11 \\
\hline
& \overline{32}
\end{array}
$$

So that about one third of the weight is chlorite of lime, to which alone the bleaching powers of the substance are owing. He admits a fact, rather inconsistent with this opinion, that bleaching powder does not attract moisture from the atmosphere with nearly so much rapidity as might be expected from a mixture containing two thirds of its weight of so deliquescent a salt as muriate of lime; unless this indeed be prevented by the chloride and chlorite being united into a double salt, which is a mere conjecture without either proof or analogy. And further, when dilute sulphuric or muriatic acid is poured upon bleaching powder, a profusion of chlorine is given out immediately, which he also admits to be inconsistent with the notion of its being a mixture of chloride of calcium and chlorite of lime, for no such evolution takes place when the above acids are mixed with solutions of chloride of calcium and chlorate of potash. Though I am of opinion that bleaching powder is simply a chloride of lime, in which the lime corresponds to the water in the aqueous chlorine, yet I cannot see the truth or appositeness of his last reason, because chlorine is certainly given out when chlorate of potash is acted upon by dilute muriatic acid, as any man may prove by adding to a mixture of these two substances a vegetable color; for it will be speedily blanched. Dr. Thomson considers the chloride which is at present made in Mr. Tennant's great factory, as containing one atom of chlorine associated with one atom of lime, or, taking his numbers, as consisting of

$$
\begin{array}{ll}
\text{Hydrate of lime} & 4 \cdot 625 \\
\text{Chlorine} \quad - & 4 \cdot 5
\end{array}
$$

Or nearly equal weights of the chlorine and the base; indicating a surprising degree of excellence in the preparation. The average commercial samples of bleaching powder from different factories which I examined some years ago, did not possess nearly that strength; but varied in their quantity of chlorine from 20 to 28 per cent. In my synthetic experiments related above, the greatest quantity of chlorine that would combine with the atomic hydrate of lime, was in the proportion of 130 to 200; but there is no doubt that if the lime contains additional water, it will condense more gas. I have never seen a chloride of lime of the strength mentioned by Dr. Thomson, and I should think there must be some fallacy in his statements. I have recorded in the paper above quoted an experiment which proves that with additional moisture, a chloride of lime may be obtained of the following composition : —

$$
\begin{array}{ll}
\text{Chlorine} & 39 \cdot 5 \\
\text{Lime} \quad - & 39 \cdot 9 \\
\text{Water} \quad - & 20 \cdot 6 \\
\hline
& \overline{100 \cdot 0}
\end{array}
$$

In the article BLEACHING, of the Encyclopædia Britannica, Dr. Thomson deduces from a test trial of Mr. Crum, that the best bleaching powder is a compound of 1 atom chlorite of lime = 11, 3 atoms chloride of calcium = 21, and 8 atoms of water = 9. " But," adds he, " in general the whole lime is not accurately saturated with chlorine. Accordingly, when the bleaching powder is dissolved in water a small residue almost always remains undissolved. Unless the powder be fresh made, a portion of chlorite is always converted into chloride of calcium. It is probable therefore that the best bleaching powder, as it comes into the hands of the bleachers, consists of

$$
\begin{array}{lll}
\text{1 atom chlorite of lime} \quad - & 11 \\
\text{3 atoms chloride of calcium} & 21 \\
\text{6 atoms water} \quad - \quad - & 6 \cdot 75 \\
\text{Impurity} \quad - \quad - & 2 \cdot 25 \\
\hline
& \overline{41 \cdot 00}
\end{array}
$$

" If we consider the bleaching powder as a compound of chlorine and lime, our mode of calculating will not be altered. Instead of 1 atom chlorite of lime, and 3 atoms chloride of calcium, we shall have 4 atoms chloride of lime, 6 atoms water, and 2·25 of impurity as before." In such ambiguity does this able chemist place this interesting compound, for theoretical reasons, of which I cannot see the value. Surely there is no difficulty in conceiving chlorine to exercise a direct attractive force towards the hydrate of lime, as it is known to do towards each of its elementary constituents, the oxygen and the calcium. Such refinements as the preceding tend merely to mystify a plain matter. Even the

cid here brought into play to form the ideal chlorite, is by his own admission
tical being. "When chlorate of potash," says Dr. Thomson, "is mixed with
acid, and made into small balls the size of a pea, if we exposé these balls to a
what lower than that of boiling water, a bright yellowish green gas separates,
r be received over mercury. Its smell is peculiar and aromatic. Water absorbs
ven times its volume of it. It destroys vegetable blues. Its constituents are—

1 volume chlorine 2·5   or 4·5.
2 volumes oxygen 2·222 or 4.

compound consists in weight of chlorine 4·5, oxygen 4=8·5. It has been called
de of chlorine, but it is more probably a teroxyde. It has been supposed by
ssess acid properties, and has therefore been called chlorous acid. But this is
t a hypothesis."

his, by the doctor's own showing, is very slender authority for renouncing our
red doctrines concerning the constitution of bleaching powder. I shall con-
emarking that the ultra-atomists are now in a dilemma about this substance;
·, and many French chemists calling it a sub-chloride, of 1 atom of chlorine to
'lime, and Dr. Thomson showing that Mr. Tennant, the greatest and best man-
of it, has produced it in the state of a chloride, or 1 atom of each. The fact is,
? of lime, as in water of ammonia, alcohol, and muriatic acid, there is no suffi-
* for definite proportion in any term short of saturation, and therefore we shall
:hloride in every gradation of strength from one per cent. of chlorine up to 40
—the strongest which I succeeded in preparing, though I passed a constant
chlorine in great excess over a pure hydrate of lime for upwards of 24 hours,
ent renewal of the surface; indeed, till it refused to absorb any more gas, as
y its remaining stationary in weight.

:OMETRY; Chlorometrie, is the name given by the French to the process for
decoloring power of any combination of chlorine, but especially of the com-
ticles, the chlorides of lime, potash, and soda. M. Gay Lussac proposed many
the following graduated method of applying indigo to this purpose. As indigo
:h in its dyeing quality, and of consequence in the proportion of chlorine re-
its decoloration, he assumes as the unity of blanching power, one litre of chlo-
measured at the mean pressure of 29·6 inches, and at the temperature of melting
volume of gas, when combined with a determinate quantity of water, is em-
est the standard solution of indigo. For this purpose a solution in sulphuric
r sample of indigo is taken, and diluted with water to such a degree that 10
of it, in a graduated tube, are decolored by that one measure of combined chlo-
Each measure of indigo solution so destroyed is called a degree, and this meas-
divided into five parts, the real test of chlorine is given to fiftieths, which is
nice. For the standard of the assays, a chloride of lime as pure and fully
s possible is taken, and dissolved in such a quantity of water, that the solution
in, or be equivalent to, one volume of chlorine gas. Calculation proves that
ion is exactly fulfilled by dissolving 4938 grammes of the said chloride in half a
ter; or in English measures, 5 gr. very nearly in 500 grain measures of water.
on, which serves for a type, indicates 10° in the assay, or proof; that is to say,
? volume destroys the color of 10 volumes of the dilute indigo solution. It may
d that a greater degree of precision is in general attainable with a weak so-
hlorine or a chloride, for example at 4° or 5°, than with one much stronger;
ly if, after a preliminary trial, the standard considerably exceeds 10°, a given
water must be added to the solution, and then the above proof must be taken.
me of water added was double, the number of degrees afterward found must
to obtain the true title of the chloride. It is, however, to be observed that
of decoloration varies with the time taken in making the mixture; the more
chlorine is added to the indigo, the less of it escapes into the atmosphere,
ore effective it becomes in destroying the color. The best mode of ob-
mparable results, is to pour suddenly into the test quantity of chlorine the
me of the indigo solution likely to be decolored; but it is requisite to find ap-
y beforehand, what quantity of indigo-blue will probably be destroyed.
mes to the verge of destruction, it is green; but yellowish-brown when en-
mposed.

ied the indigo test in many ways, but never could confide in it. The sulphu-
1 of indigo is very liable to change by keeping, and thus to lead to erroneous
he method of testing the chlorides by green sulphate of iron, described under
is in my opinion preferable to the above.

Lussac has recently proposed another proof of chlorine, founded on the same
s that by green vitriol, namely, the quantity of it requisite to raise a metallic
from a lower to a higher stage of oxydizement. He now prescribes as the
plan of chlorometry, to pour very slowly from a graduated glass tube, a

standard solution of the chloride, to be tested upon a determinate quantity of arsenious acid dissolved in muriatic acid, till the whole arsenious be converted into the arsenic acid. The value of the chloride is greater the less of it is required to produce this effect. It is easy to recognise, by a few drops of solution of indigo, the instant when all the arsenious acid has disappeared; for then the blue tint is immediately effaced, and cannot be restored by the addition of a fresh drop of the indigo solution.

In graduating the arsenical chlorometer, M. Gay Lussac takes for his unity the decoloring power of one volume of chlorine at $32°$ Fahr., and divides it into 100 parts. Suppose that we prepare a solution of chlorine containing its own volume of the gas, and an arsenious solution, such, that under a like volume, the two solutions shall reciprocally destroy each other. Let us call the first, the normal solution of chlorine, and the second, the normal arsenious solution. We shall fix at 10 grammes the weight of chloride of lime subjected to trial; and dissolve it in water, so that the total volume of the solution shall be a litre (1000 grammes measure), including the sediment. If we take a constant volume of this solution, 10 centimetres cube (10 gramme measures), for example, divided into 100 equal parts, and pour into it gradually the arsenious solution (measured by like portions), till the chlorine be destroyed, the bleaching power will be proportional to the number of portions of the arsenious solution, which the chloride shall have required. If the chloride has destroyed 100 portions of the arsenious solution, its title will be 100; if it has destroyed 80 portions, its title will be 80, &c., and so forth.

On pouring the acidulous arsenious solution into the chloride of lime, this will become very acid; the chlorine will be emitted abundantly, and the proof will be quite incorrect. If, on the contrary, we pour the solution of the chloride of lime into the arsenious solution, this evil will not occur, since the chlorine will always find plenty of arsenious acid to act upon, whatever be the dilution of the one or the other; but in this case, the standard of the chlorine is not given directly, as it is in the inverse ratio of the number of portions which are required to destroy the measures of the arsenious solution. If 50 portions of the chloride have been required, the proof will be $100 \times \frac{100}{50} = 200°$; if 200 have been required, the proof will be $100 \times \frac{100}{200} = 50°$, &c. This evil is not, however, very serious, since we have merely to consult a table, in which we can find the proof corresponding to each volume of the chloride employed for destroying the constant measure of the arsenious solution. The arsenious solution should be slightly tinged with sulphate of indigo, so as to show, by the disappearance of the color, the precise point or instant of its saturation with chlorine, that is, its conversion into arsenic acid. If the arsenious acid be pure, the normal solution may be made directly by dissolving 4·439 grammes of it in muriatic acid (free from sulphurous acid), and diluting the solution till it occupies one litre, or 1000 grammes measure. *Annales de Chimie et Physique,* LX. 225.

CHOCOLATE is an alimentary preparation of very ancient use in Mexico, from which country it was introduced into Europe by the Spaniards in the year 1520, and by them long kept a secret from the rest of the world. Linnæus was so fond of it, that he gave the specific name, *theobroma,* food of the gods, to the cacao-tree which produced it. The cacao-beans lie in a fruit somewhat like a cucumber, about 5 inches long and $3\frac{1}{2}$ thick, which contains from 20 to 30 beans, arranged in 5 regular rows with partitions between, and which are surrounded with a rose-colored spongy substance, like that of water-melons. There are fruits, however, so large as to contain from 40 to 50 beans. Those grown in the West India islands, Berbice and Demarara, are much smaller, and have only from 6 to 15; their development being less perfect than in South America. After the maturation of the fruit, when their green color has changed to a dark yellow, they are plucked, opened, their beans cleared of the marrowy substance, and spread out to dry in the air. Like almonds, they are covered with a thin skin or husk. In the West Indies they are immediately packed up for the market when they are dried; but in the Caraccas they are subjected to a species of slight fermentation, by putting them into tubs or chests, covering them with boards or stones, and turning them over every morning, to equalize the operation. They emit a good deal of moisture, lose the natural bitterness and acrimony of their taste by this process, as well as some of their weight. Instead of wooden tubs, pits or trenches dug in the ground are sometimes had recourse to for curing the beans; an operation called *earthing (terrer).* They are lastly exposed to the sun, and dried. The latter kind are reckoned the best; being larger, rougher, of a darker brown color, and, when roasted, throw off their husk readily, and split into several irregular fragments; they have an agreeable mild bitterish taste, without acrimony. The Guiana and West India sorts are smaller, flatter, smoother-skinned, lighter-colored, more sharp and bitter to the taste. They answer best for the extraction of the butter of cacao, but afford a less aromatic and agreeable chocolate. According to Lampadius, the kernels of the West India cacao beans contain, in 100 parts, besides water, 53·1 of fat or oil, 16·7 of an albuminous brown matter, which contains all the aroma of the bean, 10·91 of starch, $7\frac{1}{2}$ of gum or

e, 0·9 of lignine, and 2·01 of a reddish dye-stuff somewhat akin to the pigment of
al. The husks form 12 per cent. of the weight of the beans; they contain no fat,
sides lignine, or woody fibre, which constitutes half their weight, they yield a
own mucilaginous extract by boiling in water. The fatty matter is of the con-
: of tallow, white, of a mild agreeable taste, called butter of cacao, and not apt to
ncid by keeping. It melts only at 122° Fahr., and should, therefore, make tolera-
dies. It is soluble in boiling alcohol, but precipitates in the cold. It is obtained
ising the beans to strong pressure in canvass bags, after they have been steamed
ed in boiling water for some time. From 5 to 6 ounces of butter may be thus ob-
from a pound of cacao. It has a reddish tinge when first expressed, but it becomes
y boiling with water.
beans, being freed from all spoiled and mouldy portions, are to be gently roasted
fire in an iron cylinder, with holes in its ends for allowing the vapors to escape;
iaratus being similar to a coffee-roaster. When the aroma begins to be well de-
l, the roasting is known to be finished; and the beans must be turned out, cooled,
:ed by fanning and sifting from their husks. The kernels are then to be con-
into a paste, either by trituration in a mortar heated to 130° F., or by the follow-
enious and powerful machine. The chocolate paste has usually in France a little
incorporated with it, and a considerable quantity of sugar, which varies from
rd of its weight to equal parts. For a pound and a half of cacao, one pod of va-
sufficient. Chocolate paste improves in its flavor by keeping, and should there-
made in large quantities at a time. But the roasted beans soon lose their aroma,
sed to the air.
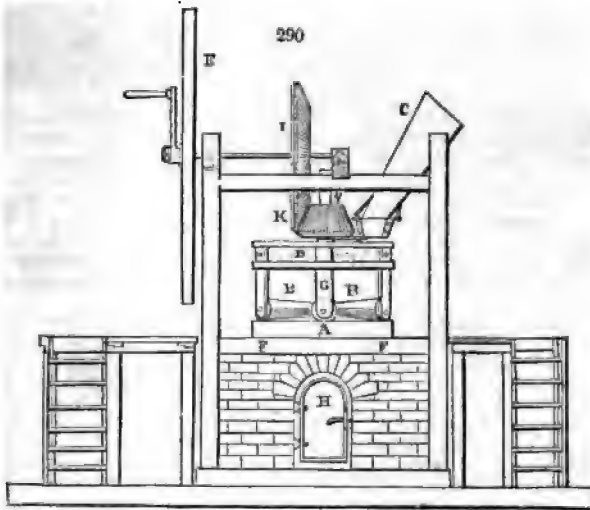
290 represents the chocolate mill. Upon the sole A, made of marble, six conical
B B, are made to run by the revolution of the upright axis or shaft q, driven by
ency of the fly wheel E and bevel wheels I K. The sole A rests upon a strong
late, which is heated by a small stove, introduced at the door H. The wooden
work F, forms a ledge, a few inches high, round the marble slab, to confine
coa in the act of trituration. c is the hopper of the mill through which the
l beans are introduced to the action of the rollers, passing first into the flat
D, to be thence evenly distributed. After the cacao has received the first tritura-
ie paste is returned upon the slab, in order to be mixed with the proper quantity
ir, and vanilla, previously sliced and ground up with a little hard sugar. When
ocolate is sufficiently worked, and while it is thin with the heat and trituration,
it be put carefully into the proper moulds. If introduced too warm, it will be
become damp and dull on the surface; and, if too cold, it will not take the proper
It must be previously well kneaded with the hands, to ensure the expulsion of
air bubble.
Barcelona, chocolate mills on this construction are very common, but they are
by a horse-gin set to work in the under story, corresponding to H in the above
The shaft G is, in this case, extended down through the marble slab, and is

surrounded at its centre with a hoop, to prevent the paste coming into contact with it. Each of these horse-mills turns out about ten pounds of fine chocolate in the hour, from a slab two feet seven inches in diameter.

Chocolate is flavored with cinnamon and cloves, in several countries, instead of the more expensive vanilla. In roasting the beans, the heat should be at first very slow, to give time to the humidity to escape; a quick fire hardens the surface, and injures the process. In putting the paste into the tin plate, or other moulds, it must be well shaken down, to ensure its filling up all the cavities, and giving the sharp and polished impression so much admired by connoisseurs. Chocolate is sometimes adulterated with starch; in which case it will form a pasty consistenced mass when treated with boiling water. The harder the slab upon which the beans are triturated, the better; and hence porphyry is far preferable to marble. The grinding rollers of the mill should be made of iron, and kept very clean.

CHROMATES, saline compounds of chromic acid with the bases. See CHRO-MIUM.

CHROMIC ACID; see CHROMIUM.

CHROMIUM. The only ore of this metal, which occurs in sufficient abundance for the purposes of art, is the octohedral chrome-ore, commonly called chromate of iron, though it is rather a compound of the oxydes of chromium and iron. The fracture of this mineral is uneven; its lustre imperfect metallic; its color between iron-black and brownish-black, and its streak brown. Its specific gravity, in the purest state, rises to 4·5; but the usual chrome-ore found in the market varies from 3 to 4. According to Klaproth, this ore consists of oxyde of chromium, 43; protoxyde of iron, 34·7; alumina, 20·3; and silica, 2; but Vauquelin's analysis of another specimen gave as above, respectively, 55·5, 33, 6, and 2. It is infusible before the blowpipe; but it acts upon the magnetic needle, after having been exposed to the reducing smoky flame. It is entirely soluble in borax, at a high blowpipe heat, and imparts to it a beautiful green color.

Chrome-ore is found at the Bare Hills, near Baltimore, in Maryland; in the Shetland Isles, Unst and Fetlar; the department of Var, in France, in small quantity; and near Portsoy, in Banffshire; as also in Silesia and Bohemia.

The chief application of this ore is to the production of chromate of potash, from which salt the various other preparations of this metal used in the arts are obtained. The ore, freed, as well as possible, from its gangue, is reduced to a fine powder, by being ground in a mill under ponderous edge-wheels, and sifted. It is then mixed with one third or one half its weight of coarsely bruised nitre, and exposed to a powerful heat, for several hours, on a reverberatory hearth, where it is stirred about occasionally. In the large manufactories of this country, the ignition of the above mixture in pots is laid aside, as too operose and expensive. The calcined matter is raked out, and lixiviated with water. The bright yellow solution is then evaporated briskly, and the chromate of potash falls down in the form of a granular salt, which is lifted out from time to time from the bottom with a large ladle, perforated with small holes, and thrown into a draining-box. This saline powder may be formed into regular crystals of neutral chromate of potash, by solution in water and slow evaporation; or it may be converted into a more beautiful crystalline body, the bichromate of potash, by treating its concentrated solution with nitric, muriatic, sulphuric, or acetic acid, or, indeed, any acid exercising a stronger affinity for the second atom of the potash than the chromic acid does.

Bichromate of potash, by evaporation of the above solution, and slow cooling, may be obtained in the form of square tables, with bevelled edges, or flat four-sided prisms. They are permanent in the air, have a metallic and bitter taste, and dissolve in about one tenth of their weight of water, at 60° F.; but in one half of their weight of boiling water. They consist of chromic acid 13, potash 6; or, in 100 parts, 68·4 + 31·6. This salt is much employed in calico-printing and in dyeing; which see.

Chromate of lead, the chrome-yellow of the painter, is a rich pigment of various shades, from deep orange to the palest canary yellow. It is made by adding a limpid solution of the neutral chromate (the above granular salt) to a solution, equally limpid, of acetate or nitrate of lead. A precipitate falls, which must be well washed, and carefully dried out of the reach of any sulphureted vapors. A lighter shade of yellow is obtained by mixing some solution of alum, or sulphuric acid, with the chromate, before pouring it into the solution of lead; and an orange tint is to be procured by the addition of subacetate of lead, in any desired proportion.

For the production of chromate of potash from chrome ore, various other processes have been recommended. The following formulæ, which have been verified in practice, will prove useful to the manufacturers of this important article:—

I. Two parts of chrome ore, containing about 50 per cent. of protoxyde of chromium:
   One part of saltpetre.

Four parts of chrome ore, containing 34 per cent. of protoxyde of chromium.
Two parts of potashes.
One part of saltpetre.
Four parts of chrome ore.   —   34   —
Two of potashes.
Four tenths of a part of peroxyde of manganese.
Three parts of chrome ore.
Four parts of saltpetre.
Two parts of argal.

ome manufacturers have contrived to effect the conversion of the oxyde into an acid, of course to form the chromate of potash, by the agency of potash alone, in a calcining ace, or in earthen pots fired in a pottery kiln.

fter lixiviating the calcined mixtures with water, if the solution be a tolerably pure mate of potash, its value may be inferred, from its specific gravity, by the following e : —

t specific gravity 1·28 it contains about 50 per cent. of the salt.

1·21	33
1·18	25
1·15	20
1·12	16
1·11	14
1·10	12

i making the red bichromate of potash from these solutions of the yellow salt, nitric was at first chiefly used; but in consequence of its relatively high price, sulphuric, iatic, or acetic acid has been frequently substituted upon the great scale.

here is another application of chrome which merits some notice here; that of its green le to dyeing and painting on porcelain. This oxyde may be prepared by decomposing, i heat, the chromate of mercury, a salt made by adding to nitrate of protoxyde of mer-r, chromate of potash, in equivalent proportions. This chromate has a fine cinnabar when pure; and, at a dull red heat, parts with a portion of its oxygen and its curial oxyde. From M. Dulong's experiments it would appear, that the purest mate of mercury is not the best adapted for preparing the oxyde of chrome to be l in porcelain painting. He thinks it ought to contain a little oxyde of manganese chromate of potash, to afford a green color of a fine tint, especially for pieces that to receive a powerful heat. Pure oxyde of chrome preserves its color well enough muffle furnace; but, under a stronger fire, it takes a dead-leaf color.

he green oxyde of chrome has come so extensively into use as an enamel color for elain, that a fuller account of the best modes of manufacturing it must prove accept-to many of my readers.

hat oxyde, in combination with water, called the hydrate, may be economically ared by boiling chromate of potash, dissolved in water, with half its weight of ers of sulphur, till the resulting green precipitate ceases to increase, which may be ly ascertained by filtering a little of the mixture. The addition of some potash lerates the operation. This consists in combining the sulphur with the oxygen of chromic acid, so as to form sulphuric acid, which unites with the potash of the mate into sulphate of potash, while the chrome oxyde becomes a hydrate. An i quantity of potash facilitates the deoxydizement of the chromic acid by the forma-of hyposulphite and sulphuret of potash, both of which have a strong attraction xygen. For this purpose the clear lixivium of the chromate of potash is sufficiently , though it should hold some alumina and silica in solution, as it generally does. hydrate may be freed from particles of sulphur by heating dilute sulphuric acid . it, which dissolves it; after which it may be precipitated, in the state of a mate, by carbonate of potash, not added in excess.

r calcining a mixture of bichromate of potash and sulphur in a crucible, chromic is also decomposed, and a hydrated oxyde may be obtained; the sulphur being y converted into sulphuret of potassium, and partly into sulphuric acid (at the nse of the chromic acid), which combines with the rest of the potash into a mate. By careful lixiviation, these two new compounds may be washed away, and hrome green may be freed from the remaining sulphur, by a slight heat.

ebig and Wöhler have lately contrived a process for producing a subchromate of of a beautiful vermilion hue. Into saltpetre, brought to fusion in a crucible at atle heat, pure chrome yellow is to be thrown by small portions at a time. A ig ebullition takes place at each addition, and the mass becomes black, and con-es so while it is hot. The chrome yellow is to be added till little of the saltpetre ins undecomposed, care being taken not to overheat the crucible, lest the color he mixture should become brown. Having allowed it to settle for a few minutes, ng which the dense basic salt falls to the bottom, the fluid part, consisting of

chromate of potash and saltpetre, is to be poured off, and it can be employed again in preparing chrome yellow. The mass remaining in the crucible is to be washed with water, and the chrome red being separated from the other matters, is to be dried after proper edulcoration. It is essential for the beauty of the color, that the saline solution should not stand long over the red powder, because the color is thus apt to become of a dull orange hue. The fine crystalline powder subsides so quickly to the bottom after every ablution, that the above precaution may be easily observed.

As *Chromic Acid* will probably ere long become an object of interest to the calico printer, I shall describe here the best method of preparing it. To 100 parts of yellow chromate of potash, add 136 of nitrate of barytes, each in solution. A precipitate of the yellow chromate of barytes falls, which being washed and dried would amount to 130 parts. But while still moist it is to be dissolved in water by the intervention of a little nitric acid, and then decomposed by the addition of the requisite quantity of sulphuric acid, whereby the barytes is separated, and the chromic acid remains associated with the nitric acid, from which it can be freed by evaporation to dryness. On re-dissolving the chromic acid residuum in water, filtering and evaporating to a proper degree, 50 parts of chromic acid may be obtained in crystals.

This acid may also be obtained from chromate of lime, formed by mixing chromate of potash and muriate of lime; washing the insoluble chromate of lime which precipitates, and decomposing it by the equivalent quantity of oxalic acid, or for ordinary purposes even sulphuric acid may be employed.

Chromic acid is obtained in quadrangular crystals, of a deep red color; it has a very acrid and styptic taste. It reddens powerfully litmus paper. It is deliquescent in the air. When heated to redness it emits oxygen, and passes into the deutoxyde. When a little of it is fused along with vitreous borax, the compound assumes an emerald green color.

As chromic acid parts with its last dose of oxygen very easily, it is capable in certain styles of calico printing of becoming a valuable substitute for chlorine, where this more powerful substance would not from peculiar circumstances be admissible. For this ingenious application, the arts are indebted to that truly scientific manufacturer, M. Daniel Kœchlin, of Mülhouse. He discovered that whenever chromate of potash has its acid set free by its being mixed with tartaric or oxalic acid, or a neutral vegetable substance, (starch or sugar for example,) and a mineral acid, a very lively action is produced, with disengagement of heat, and of several gases. The result of this decomposition is the active reagent, chromic acid, possessing valuable properties to the printer. Watery solutions of chromate of potash and tartaric acid being mixed, an effervescence is produced which has the power of destroying vegetable colors. But this power lasts no longer than the effervescence. The mineral acids react upon the chromate of potash only when vegetable coloring matter, gum, starch, or a vegetable acid are present, to determine the disengagement of gas. During this curious change carbonic acid is evolved; and when it takes place in a retort, there is condensed in the receiver a colorless liquid, slightly acid, exhaling somewhat of the smell of vinegar, and containing a little empyreumatic oil. This liquid heated with the nitrates of mercury or silver reduces these metals. On these principles M. Kœchlin discharged indigo blue by passing the cloth through a solution of chromate of potash, and printing nitric acid thickened with gum upon certain spots. It is probable that the employment of chromic acid would supersede the necessity of having recourse in many cases to the more corrosive chlorine.

The following directions have been given for the preparation of a *blue oxyde* of chrome. The concentrated alkaline solution of chromate of potash is to be saturated with weak sulphuric acid, and then to every 8 lbs. is to be added 1 lb. of common salt, and half a pound of concentrated sulphuric acid; the liquid will now acquire a green color. To be certain that the yellow color is totally destroyed, a small quantity of the liquor is to have potash added to it, and filtered; if the fluid is still yellow, a fresh portion of salt and of sulphuric acid is to be added; the fluid is then to be evaporated to dryness, redissolved, and filtered; the oxyde of chrome is finally to be precipitated by caustic potash. It will be of a greenish-blue color, and being washed, must be collected upon a filter.

Chromate of Potash, adulteration of, to detect. The chromate of potash has the power of combining with other salts up to a certain extent without any very sensible change in its form and appearance; and hence it has been sent into the market falsified by very considerable quantities of sulphate and muriate of potash, the presence of which has often escaped observation, to the great loss of the dyers who use it so extensively. The following test process has been devised by M. Zuber, of Mülhouse. Add a large excess of tartaric acid to the chromate in question, which will decompose it, and produce in a few minutes a deep amethyst color. The supernatant liquor will, if the chromate be pure, afford now no precipitate with the nitrates of barytes or silver; whence the absence of the sulphates and muriates may be inferred. We must, however, use dilute solutions of the chromate and acid, lest bitartrate of potash be precipitated, which will take place if less than 60 parts of water be employed. Nor must

re test the liquid till the decomposition be complete, and till the color verge rather toward he green than the yellow. Eight parts of tartaric acid should be added to one of chromate to obtain a sure and rapid result. If nitrate of potash (saltpetre) is the adulterating agredient, it may be detected by throwing it on burning coals, when deflagration will ensue. The green color is a certain mark of the transformation of the chromic acid partially into the chrome oxyde; which is effected equally by the sulphurous acid and sulphureted hydrogen. Here this metallic acid is disoxygenated by the tartaric, as has been long mown. The tests which I should prefer, are the nitrates of silver and baryta, having previously added so much nitric acid to the solution of the suspected chromate, as to prevent the precipitation of the chromate of silver or baryta. The smallest adulteration by sulphates or muriates will thus be detected.

CINNABAR; the native red sulphuret of mercury. It occurs sometimes crystallized n rhomboids; has a specific gravity varying from 6·7 to 8·2; a flat conchoidal fracture; a fine grained; opaque; has an adamantine lustre, and a color passing from cochineal to ruby red. The fibrous and earthy cinnabar has a scarlet hue. It is met with disseminated in smaller or larger lumps in veins, which are surrounded by a black clay, and is associated with native quicksilver, amalgam, with iron-ore, lead-glance, blende, copper-ore, gold, &c. Its principal localities are Almaden in Spain, Idria in the Schiefergebirge, Kremnitz and Schemnitz in Hungary; in Saxony, Bavaria, Bohemia, Nassau, China, Japan, Mexico, Columbia, Peru. It consists of two primes of sulphur, = 32·240, combined with one of mercury, = 202,863; or in 100 parts of 12·7 sulphur + 87·3 mercury. It is the most prolific ore of this metal; and is easily smelted by exposing a mixture of it with iron or lime to a red heat in retorts. Factitious cinnabar is called in commerce VERMILION, which see, as also MERCURY.

CINNAMON. (*Cannelle*, Fr.; *Zimmt*, Germ.) Is the inner bark of the *laurus cinnamomum*, a handsome-looking tree which grows naturally to the height of 18 or 20 feet, in Java, Sumatra, Ceylon, and other islands in the East Indian seas. It has been transplanted to the Antilles, particularly Guadaloupe and Martinique, as well as Cayenne, but there it produces a bark of very inferior value to the Oriental.

Cinnamon is gathered twice a year, but not till after the tree has attained to a certain age and maturity. The young twigs yield a bark of better quality than the larger branches. The first and chief harvest takes place from April to August; the second, from November to January. After having selected the proper trees, all the branches more than three years old are cut off; the epidermis is first removed with a two-edged pruning knife, then a longitudinal incision is made through the whole extent of the bark, and lastly, with the bluntest part of the knife, the true bark is carefully stripped off in one piece. All these pieces of bark are collected, the smaller ones are laid within the larger, and in this state they are exposed to the sun, whereby in the progress of drying, they become rolled into the shape of a quill. These convoluted pieces are formed into oblong bundles of 20 or 30 lbs. weight, which are placed in warehouses, sorted and covered with mats. Good cinnamon should be as thin as paper, have its peculiar aromatic taste, without burning the tongue, and leave a sweetish flavor in the mouth. The broken bits of cinnamon are used in Ceylon for procuring the essential oil by distillation. 445,367 lbs. of cinnamon were imported into this kingdom in 1835, of which 16,604 only were retained for internal consumption.

CITRIC ACID. (*Acide citrique*, Fr.; *Citronensaure*, Germ.) Scheele first procured this acid in its pure state from lemon juice, by the following process. The juice put into a large tub, is to be saturated with dry chalk in fine powder, noting carefully the quantity employed. The citrate of lime which precipitates, being freed from the supernatant foul liquor, is to be well washed with repeated affusion and decantation of water. For every 10 pounds of chalk employed, nine and a half pounds of sulphuric acid, diluted with six times its weight of water, are to be poured while warm upon the citrate of lime, and well mixed with it. At the end of twelve hours, or even sooner, the citrate will be all decomposed, dilute citric acid will float above, and sulphate of lime will be found at the bottom. The acid being drawn off, the calcareous sulphate must be thrown on a canvass filter, drained, and then washed with water to abstract the whole acid.

The citric acid thus obtained may be evaporated in leaden pans, over a naked fire, till t acquires the specific gravity 1·13; after which it must be transferred into another vessel, evaporated by a steam or water bath till it assumes a sirupy aspect, when a pellicle appears first in patches and then over the whole surface. This point must be watched with great circumspection, for if it be passed, the whole acid runs a risk of being spoiled by carbonization. The steam or hot water must be instantly withdrawn, and the concentrated acid put into a crystallizing vessel in a dry, but not very cold apartment. At the end of four days, the crystallization will be complete. The crystals must be drained, redissolved in a small portion of water, the solution set aside to settle its impurities, then decanted, re-evaporated, and re-crystallized. A third or fourth crystallization may be necessary to obtain a colorless acid.

If any citrate of lime be left undecomposed by the sulphuric acid, it will dissolve in the citric acid, and obstruct its crystallization, and hence it will be safer to use the slightest excess of sulphuric acid, than to leave any citrate undecomposed. There should not however be any great excess of sulphuric acid. If there be, it is easily detected by nitrate of barytes, but not by the acetate of lead as prescribed by some chemical authors; because the citrate of lead is not very soluble in the nitric acid, and might thus be confounded with the sulphate, whereas citrate of barytes is perfectly soluble in that test acid. Sometimes a little nitric acid is added with advantage to the solution of the colored crystals, with the effect of whitening them.

Twenty gallons of good lemon juice will afford fully ten pounds of white crystals of citric acid.

Attempts were made, both in the West Indies and Sicily, to convert the lime and lemon juice into citrate of lime, but they seem to have failed through the difficulty of drying the citrate for shipment.

The crystals of citric acid are oblique prisms with four faces, terminated by dihedral summits, inclined at acute angles. Their specific gravity is 1·617. They are unalterable in the air. When heated, they melt in their water of crystallization; and at a higher heat, they are decomposed. They contain 18 per cent. of water, of which one half may be separated in a dry atmosphere, at about 100° F., when the crystals fall into a white powder.

Citric acid in crystals is composed by my analysis of carbon 35·8, oxygen 59·7, and hydrogen 4·5; results which differ very little from those of Dr. Prout, subsequently obtained. I found its atomic weight to be 8·375, compared to oxygen 1,000. I cannot account for Berzelius's statements relative to the composition of this acid.

Citric acid in somewhat crude crystals is employed with much advantage in calicoprinting. If adulterated with tartaric acid, the fraud may be detected by adding potash to the solution of the acid, which will occasion a precipitate of cream of tartar.

CIVET. (*Civette*, Fr.; *Zibeth*, Germ.) This substance approaches in smell to musk and ambergris; it has a pale yellow color, a somewhat acrid taste, a consistence like that of honey, and a very strong aromatic odor. It is the product of two small quadrupeds of the genus *viverra* (*v. zibetha* and *v. ciretta*), of which the one inhabits Africa, the other Asia. They are reared with tenderness, especially in Abyssinia. The civet is contained in a sac, situated between the anus and the parts of generation in either sex. The animal frees itself from an excess of this secretion by a contractile movement which it exercises upon the sac, when the civet issues in a vermicular form, and is carefully collected. The negroes are accustomed to increase the secretion by irritating the animal; and likewise introduce a little butter, or other grease, by the natural slit in the bag, which mixes with the odoriferous substance, and increases its weight. It is employed only in perfumery.

According to M. Boutron-Chalard, it contains a volatile oil, to which it owes its smell, some free ammonia, resin, fat, an extractiform matter, and mucus. It affords, by calcination, an ash, in which there are some carbonate and sulphate of potash, phosphate of lime, and oxyde of iron.

CLAY (*Argile*, Fr.; *Thon*, Germ.) is a mixture of the two simple earths, alumina and silica, generally tinged with iron. Lime, magnesia, with some other coloring metallic oxydes, are occasionally present in small quantities in certain natural clays.

The different varieties of clay possess the following common characters :—

1. They are readily diffusible through water, and are capable of forming with it a plastic ductile mass, which may be kneaded by hand into any shape. This plasticity exists, however, in very different degrees in the different clays.

2. They concrete into a hard mass upon being dried, and assume, upon exposure to the heat of ignition, a degree of hardness sometimes so great as to give sparks by collision with hardened steel. In this state they are no longer plastic with water, even when pulverized. Tolerably pure clays, though infusible in the furnace, become readily so by the admixture of lime, iron, manganese, &c.

3. All clays, even when previously freed from moisture, shrink in the fire in virtue of the reciprocal affinity of their particles; they are very absorbent of water in their dry state, and adhere strongly to the tongue.

4. Ochrey, impure clays, emit a disagreeable earthy smell when breathed upon.

Brongniart distributes the clays into :—

1. Fire-clays, (*argiles apyres*, Fr.; *feuerfeste*, Germ.)
2. Fusible, (*schmelzbare*, Germ.)
3. Effervescing (*brausende*, Germ.), from the presence of chalk.
4. Ochrey (*ocreuses*, Fr.; *ockrige*, Germ.)

Fire-clay is found in the greatest abundance and perfection for manufacturing purposes in,

1. *Slate-clay*. (*Thon-schiefer*, Germ.) Its color is gray or grayish-yellow. Massive,

· glimmering from admixture of particles of mica. Fracture slaty, approaching nes to earthy. Fragments tabular. Soft, sectile, and easily broken. Sp. gr.=2·6. s to the tongue, and breaks down in water. It occurs along with *pit coal*; which Slate-clay is ground, and reduced into a paste with water, for making fire-bricks; ich purpose it should be as free as possible from lime and iron.

'ommon *clay or loam.*—This is an impure coarse pottery clay, mixed with iron ochre, casionally with mica. It has many of the external characters of plastic clay. It to the touch, and forms, with water, a somewhat tenacious paste; but is in gen-is compact, more friable, than the plastic clays, which are more readily diffusible er. It does not possess the property of acquiring in water that commencement of eency which the purer clays exhibit. Although soft to the touch, the common ants unctuosity, properly so called. The best example of this argillaceous sub-is afforded in the London clay formation, which consists chiefly of bluish or black-y, mostly very tough. Those of its strata which effervesce with acids partake nature of marl. This clay is fusible at a strong heat, in consequence of the iron e which it contains. It is employed in the manufacture of bricks, tiles, and coarse ware.

otter's *clay, or Plastic clay.*—This species is compact, soft, or even unctuous to eh, and polishes with the pressure of the finger; it forms, with water, a tenacious, ctile, and somewhat translucent paste. It is infusible in a porcelain kiln, but as-n it a great degree of hardness. Werner calls it *pipe-clay.* Good plastic clay s white, or if gray before, becomes white in the porcelain kiln.

geological position of the plastic clay is beneath the London clay, and above the hich covers the chalk formation. The plastic clay of the Paris basin is described isting of two beds separated by a bed of sand. The lower bed is the proper plas-. The plastic clay of *Abondant*, near the forest of Dreux, analyzed by Vauquelin,

, 43·5; alumina, 33·2; lime, 0·35; iron, 1; water, 18.

clay is employed as a fire clay for making the bungs or *seggars*, or coarse earthen-ises, in which china ware is fired.

plastic clay of Dorsetshire and Devonshire supplies the great Staffordshire potte-t is gray colored, less unctuous than that of Dreux, and consequently more friable. nes white in the pottery kiln, and is infusible at that heat. It causes no efferves-rith nitric acid, but falls down quickly in it, and becomes higher colored. Its re-ness allows of a harder glaze being applied to the ware formed from it without the heat requisite for making the glaze flow, affecting the biscuit either in shape :. "Most of the plastic clays of France," says M. Brongniart, "employed for e ware, have the disadvantage of reddening a little in a somewhat strong heat; ice it becomes necessary to coat them with a soft glaze, fusible by means of excess at a low heat, in order to preserve the white appearance of the biscuit. Such a as a dull aspect, and cracks readily into innumerable fissures by alternations of cold water." Hence one reason of the vast inferiority of the French stone-ware English.

rcelain *clay, or Kaolin earth.*—The Kaolins possess very characteristic properties. e friable in the hand, meager to the touch, and difficultly form a paste with water. reed from the coarse and evidently foreign particles interspersed through them, absolutely infusible in the porcelain kiln, and retain their white color unaltered. arden with heat like other clays, and perhaps in a greater degree; but they do not an equal condensation or solidity, at least when they are perfectly pure. The in general appear to consist of alumina and silica in nearly equal proportions. the Kaolin clays contain some spangles of mica, which betray their origin from rated granite.

origin may be regarded as one of their most distinctive features. Almost all celain clays are evidently derived from the decomposition of the feldspars, gran-1 principally those rocks of feldspar and quartz, called graphic granite. Hence, to be found only in primitive mountain districts, among banks or blocks of gran-ing thin seams or partings between them. In the same partings, quartz and cur, being relics of the granite; while some seams of Kaolin retain the external feldspar.

most valuable Kaolins have been found—
hina and Japan. The specimens imported from these countries appear pretty but are more unctuous to the touch, and more micaceous than the porcelain clays ce.
xeny. The Kaolin employed in the porcelain manufactories of that country has a ellow or flesh color, which disappears in the kiln, proving, as Wallerius observed, a tint is not owing to any metallic matter.
rance, at Saint-Yriex-la-Perche, about 10 leagues from Limoges. The Kaolin

occurs there in a bed, or perhaps a vein of beds of granite, or rather of that feldspar rock called Pe-tun-tse, which exists here in every stage of decomposition. This Kaolin is generally white, but sometimes a little yellowish, with hardly any mica. It is meager to the touch, and some beds include large grains of quartz, called pebbly by the China manufacturers. This variety, when ground, affords, without the addition of any fusible ingredient, a very transparent porcelain.

Near Bayonne. A Kaolin possessing the lamellated structure of feldspar, in many places. The rock containing it is a graphic granite in every stage of decomposition.

In England, in the county of Cornwall. This Kaolin or China clay is very white, and more unctuous to the touch than those upon the continent of Europe mentioned above. Like them it results from the decomposition of the feldspars and granites, occurring in the middle of these rocks. Mr. Wedgewood found it to contain 60 of alumina or pure clay, and 40 of silica, in 100 parts.

Pure clay, the alumina of the chemist, is absolutely infusible; but when subjected to the fire of a porcelain kiln, it contracts into about one half of its total bulk. It must, however, be heated very cautiously, otherwise it will decrepitate and fly in pieces, owing to the sudden expansion into steam of the water combined with its particles, which is retained with a considerable attractive force. It possesses little plasticity, and consequently affords a very short paste, which is apt to crack when kneaded into a cake.

It is not only infusible by itself, but it will not dissolve in the fusible glasses; making them merely opaque. If either lime or silica be added separately to pure clay, in any proportion, the mixture will not melt in the most violent furnace; but if alumina, lime, and silica be mixed together, the whole melts, and the more readily, the nearer the mixture approaches to the following proportions:—1 of alumina, 1 of lime, and 3 of sand. If the sand be increased to five parts, the compound becomes infusible. These interesting facts show the reciprocal action of those earths which are mixed most commonly in nature with alumina.

Iron in small quantity, but in a state not precisely determined, though probably of protoxyde, does not color the clays till they are subjected to a powerful heat. There are very white clays, such as those of Montereau, which do not become red till calcined in the porcelain kiln; the oxyde of iron contained in them, which colors them in that case, was previously imperceptible. It appears from this circumstance, that the clays fit for making fine white stone ware, as also the Kaolins adapted to the manufacture of porcelain, are very rare.

Iron, in larger proportion, usually colors the clays green or slate-blue, before they have been heated. Such clays, exposed to the action of fire, become yellow or red according to the quantity of iron which they contain. When the iron is very abundant, it renders the clays fusible; but a little lime and silica must also be present for this effect. The earthenware made with these ferruginous clays can bear but a moderate baking heat; it is thick, porous, and possesses the advantage merely of cheapness, and of bearing considerable alternations of temperature without breaking.

Alumina and the very aluminous natural clays which possess most plasticity, are apt to crack in drying, or to lose their shape. This very serious defect for the purposes of pottery is rectified, in some measure, by adding to that earth a certain quantity of sand or silica. Thus, a compound is formed which possesses less attraction for water, and dries more equably from the openness of its body. The principal causes of the distortion of earthenware vessels, are the unequal thickness of their parts, and quicker desiccation upon one side than another. Hard burnt stone-ware ground to powder, and incorporated with clay, answers still better than sand for counteracting the great and irregular contraction which natural pottery paste is apt to experience. Such ground biscuit is called *cement;* and its grains interspersed through the ware, may be regarded as so many solutions of continuity, which arrest the fissures.

The preceding observations point out the principles of those arts which employ clay for moulding by the wheel, and baking in a kiln. See PORCELAIN and POTTERY.

CLOTH, MANUFACTURE OF. See TEXTILE FABRICS, WEAVING, WOOL.

CLOTH-BINDING. Nothing places in so striking a point of view the superior taste, judgment, and resources of London tradesmen over those of the rest of the world, as the extensive substitution which they have recently made of embossed silks and calicoes for leather in the binding of books. In old libraries, cloth-covered boards indeed may occasionally be seen, but they have the meanest aspect, and are no more to be compared with our modern cloth-binding, than the *jupon* of a trull, with the ballette dress of Taglioni. The silk or calico may be dyed of any shade which use or fancy may require, impressed with gold or silver foil in every form, and variegated by ornaments in relief, copied from the most beautiful productions in nature. This new style of binding is distinguished not more for its durability, elegance, and variety, than for the economy and despatch with which it ushers the offspring of intellect into the world.

For example, should a house eminent in this line, such as that of Westleys, Friar-street, Doctors'-commons, receive 5000 volumes from Messrs. Longman & Co. upon Monday morning, they can have them all ready for publication, within the incredibly short period of two days; being far sooner than they could have rudely boarded them upon the former plan. The reduction of price is not the least advantage incident to the new method, amounting to fully 50 per cent. upon that with leather.

The dyed cloth, being cut by a pattern to the size suited to the volume, is passed rapidly through a roller press, between engraved cylinders of hard steel, whereby it receives at once the impress characteristic of the back and the sides, along with embossed designs over the surface in sharp relief. The cover, thus rapidly fashioned, is as rapidly applied by paste to the stitched and pressed volume; no time being lost in mutual adjustments; since the steel rollers turn off the former, of a shape precisely adapted to the latter. Hard glazed and varnished calico is moreover much less an object of depredation to moths, and other insects, than ordinary leather has been found to be.

COBALT. This metal, being difficult to reduce from its ores, is therefore very little known, and has not hitherto been employed in its simple state in any of the arts; but its oxyde has been extensively used on account of the rich blue color which it imparts to glass, and the glaze of porcelain and stone-ware. The principal ores of cobalt are those designated by mineralogists under the names of _arsenical cobalt_ and _gray cobalt_. The first contains, in addition to cobalt, some arsenic, iron, nickel, and occasionally silver, &c. The other is a compound of cobalt with iron, arsenic, sulphur, and nickel. Among the gray cobalts, the ore most esteemed for its purity is that of Tunaberg in Sweden. It is often in regular crystals, which possess the lustre and color of polished steel. The specific gravity of cobalt pyrites is 6·36 to 4·66. The Tunaberg variety afforded to Klaproth, cobalt, 44; arsenic, 55·5; sulphur, 0·5; so that it is an arseniuret. Others, however, contain much sulphur as well as iron. It imparts at the blowpipe a blue color to borax and other fluxes, and gives out arsenical fumes.

The ore being picked, to separate its concomitant stony matter, is pounded fine and passed through a sieve; and is also occasionally washed. The powder is then spread on the sole of a reverberatory furnace, the flue of which leads into a long horizontal chimney. Here it is exposed to calcination for several hours, to expel the sulphur and arsenic that may be present; the former burning away in sulphurous acid gas, the latter being condensed into the white oxyde or arsenious acid, whence chiefly the market is supplied with this article. This calcining process can never disengage the whole of these volatile ingredients, and there is therefore a point beyond which it is useless to push it; but the small quantities that remain are not injurious to the subsequent operations. The roasted ore is sifted anew; reduced to a very fine powder, and then mixed with 2 or 3 parts of very pure silicious sand, to be converted into what is called _zaffre_. With this product glasses are generally colored blue, as well as enamels and pottery glaze. In the works where cobalt ores are treated, a blue glass is prepared with the zaffre, which is well known under the name of smalt or azure blue. This azure is made by adding to the zaffre 2 or 3 parts of potash, according to its richness in cobalt, and melting the mixture in earthen crucibles. The fused mass is thrown out while hot into water; and is afterwards triturated and levigated in mills mounted for the purpose. There remains at the bottom of the earthen pot a metallic lump, which contains a little cobalt, much nickel, arsenic, iron, &c. This is called _speiss_.

As it is the _oxyde_ of cobalt which has the coloring quality, the calcination serves the purpose of oxydizement, as well as of expelling the foreign matters.

A finer cobalt oxyde is procured for painting upon hard porcelain, by boiling the cobalt ore in nitric acid, which converts the arsenic into an acid, and combines it with the different metals present in the mineral. These arseniates, being unequally soluble in nitric acid, may be separated in succession by a cautious addition of carbonate of soda or potash; and the arseniate of cobalt as the most soluble remains unaffected. It has a rose color, and is easily distinguishable, whence the precipitation may be stopped at the proper point. The above solution should be much diluted, and the alkali should be cautiously added, with frequent agitation.

The cobalt ores, rich in nickel, are exposed to slow oxydizement in the air, whereby the iron, cobalt, arsenic, and sulphur get oxygenated by the atmospheric moisture, but the nickel continues in the metallic state. This action of the weather must not be extended beyond a year, otherwise the nickel becomes affected, and injures the cobalt blue. The ore hereby increases in weight, from 8 to 10 per cent. _Fig._ 291 is a longitudinal section of the furnace: _fig._ 292, a horizontal section upon a level with the sole of the hearth. It is constructed for wood fuel, and the hearth is composed of fire-bricks or tiles. The vapors and gases disengaged in the roasting pass off through the flues _a a_, into the channels _b b_, and thence by _c_ into the common vent, or poison chamber. See the representation of the poison tower of Altenberg, under the

article ARSENIC. The flues are cleared out by means of openings left at suitable situations in the brick-work of the chimneys.
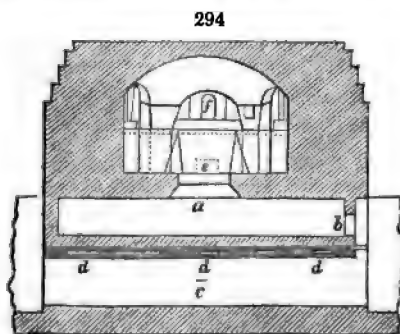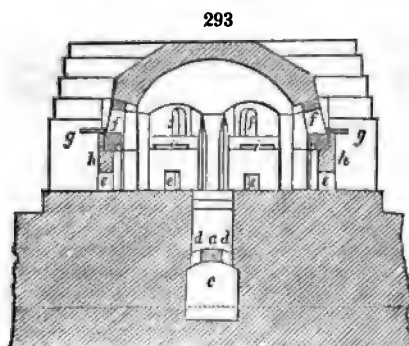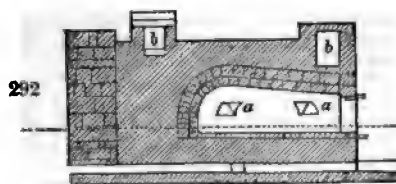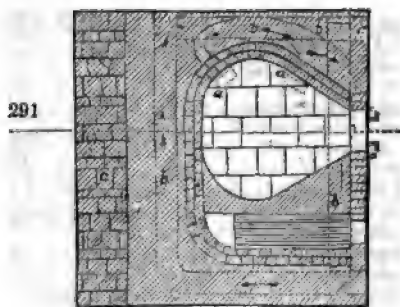
The azure manufacture is carried on chiefly in winter, in order that the external cold may favor the more complete condensation of the acids of arsenic. From 3 to 5 cwt. of Schlich (pasty ore) are roasted at one operation, and its bed is laid from 5 to 6 inches thick. After two hours, it must be turned over; and the stirring must be repeated every half hour, till no more arsenic is observed to exhale. The process being then finished, the ore must be raked out of the furnace, and another charge introduced.

The duration of the roasting is regulated partly by the proportion of sulphur and arsenic present, and partly by the amount of nickel; which must not be suffered to become oxydized, lest it should spoil the color of the smalt. The latter ores should be but slightly roasted, so as to convert the nickel into *speiss*. The roasted ore must be sifted in a safety apparatus. The loss of weight in the roasting amounts, upon the average, to 36 per cent. The roasted ore has a brownish gray hue, and is called *safflor* in German, and is distributed into different sorts. F F S is the finest *safre*; F S, fine; O S, ordinary; and M S, middling. These varieties proceed from various mixtures of the calcined ores. The roasted ore is ground up along with sand, elutriated, and, when dry, is called *zaffre*. It is then mixed with a sufficient quantity of potash for converting the mixture into a glass.

Figs. 293 and 294, represent a round smalt furnace, in two vertical sections, at right angles to each other. The fire-place is vaulted or arched; the flame orifice *a*, is in the middle of the furnace; *b* is the feed hole; *c*, a tunnel which serves as an ash-pit, and to supply air; *d*, openings through which the air arrives at the fuel, the wood being placed upon the vault; *e*, knee holes for taking out the scoriæ from the pot bottoms; *f*, working orifices, with cast-iron plates *g*, in front of them. Under these are the additional outlets *h*. The smoke and flame pass off through the orifices *i*, which terminate in expanded flues, where the sand may be calcined or the wood may be baked. Eight hours are sufficient for one vitrifying operation, during which the glass is stirred about several times in the earthen melting pots.

The preparation of the different shades of blue glass is considered a secret in the smelting works; and marked with the following letters :—F F F C, the finest; F C,

fine; M C, middling; O C, ordinary. A melting furnace, containing 8 pots of glass, produces in 24 hours, from 24 cwts. of the mixture, 19 cwts. of blue glass; and from ½ to ⅔ cwt. of scoriæ or speiss (*speise*). The composition *speise*, according to Berthier, is—nickel, 49·0; arsenic, 37·8; sulphur, 7·8; copper, 1·6; cobalt, 3·2 in 100. Nickel, arsenic, and sulphur, are its essential constituents; the rest are accidental, and often absent. The freer the cobalt ore is from foreign metals, the finer is the color, and the deeper is the shade; paler tints are easily obtained by dilution with more glass. The presence of nickel gives a violet tone.

The production of smalt in the Prussian states amounted, in 1830, to 7452½ cwts.; and in Saxony to 9697 cwts.; in 1825, to 12,310 cwts.

One process for making fine smalt has been given under the title AZURE; I shall introduce another somewhat different here.

The ore of cobalt is to be reduced to very fine powder, and then roasted with much care. One part, by weight, is next to be introduced, in successive small portions, into an iron vessel, in which three parts of acid sulphate of potassa have been previously fused, at a moderate temperature. The mixture, at first fluid, soon becomes thick and firm, when the fire is to be increased, until the mass is in perfect fusion, and all white vapors have ceased. It is then to be taken out of the crucible with an iron ladle, the crucible is to be recharged with acid sulphate of potash, and the operation continued as before, until the vessel is useless. The fused mass contains sulphate of cobalt, neutral sulphate of potassa, and arseniate of iron, with a little cobalt. It is to be pulverized, and boiled in an iron vessel, with water, as long as the powder continues rough to the touch. The white, or yellowish white residue, may be allowed to separate from the solution, either by deposition or filtration. Carbonate of potassa, free from silica, is then to be added to the solution, and the carbonate of cobalt thrown down is to be separated and well washed, if possible, with warm water; the same water may be used to wash other portions of the fused mass. The filtered liquid which first passes is a saturated solution of sulphate of potassa: being evaporated to dryness in an iron vessel, it may be reconverted into acid sulphate by fusing it with one half its weight of sulphuric acid: this salt is then as useful as at first.

The oxyde of cobalt thus obtained contains no nickel; so little oxyde of iron is present, that infusion of galls does not show its presence; it may contain a little copper, if that metal exists in the ore, but it is easily separated by the known methods. Sometimes sulphureted hydrogen will produce a yellow brown precipitate in the solution of the fused mass; this, however, contains no arsenic, but is either sulphuret of antimony or bismuth, or a mixture of both.

It has been found advantageous to add to the fused mass sulphate of iron, calcined to redness, and one tenth of nitre when the residue is arseniate of iron, and contains no arseniate of cobalt. There is then no occasion to act upon the residue a second time for the cobalt in it.

This process is founded on the circumstances that the sulphate of cobalt is not decomposed by a red heat, and that the arseniates of iron and cobalt are insoluble in all neutral liquids. It is quite evident, that, to obtain a perfect result, the excess of acid in the bisulphate of potassa must be completely driven off by the red heat applied.

110,646 lbs. of smalts were imported into the United Kingdom in 1835, and 96,949 were retained for home consumption. In 1834, only 16,223 lbs. were retained.

In 1835, 322,562 lbs. of zaffres were imported, and 336,824 are stated to have been retained, which is obviously an error. 284,000 lbs. were retained in 1834.

COCCULUS INDICUS, or Indian berry, is the fruit of the *Menispermum Cocculus*, a large tree, which grows upon the coasts of Malabar, Ceylon, &c. The fruit is blackish, and of the size of a large pea. It owes its narcotic and poisonous qualities to the vegeto-alkaline chemical principle called *picrotoxia*, of which it contains about one fiftieth part of its weight. It is sometimes thrown into waters to intoxicate or kill fishes; and it is said to have been employed to increase the inebriating qualities of ale or beer. Its use for this purpose is prohibited by act of parliament, under a penalty of 200*l.* upon the brewer, and 500*l.* upon the seller of the drug.

COCHINEAL was taken in Europe at first for a seed, but was proved by the observations of Lewenhoeck to be an insect, being the female of that species of shield-louse, or *coccus*, discovered in Mexico, so long ago as 1518. It is brought to us from Mexico, where the animal lives upon the *cactus opuntia* or *nopal*. Two sorts of cochineal are gathered—the wild, from the woods, called by the Spanish name *grana silvestra*; and the cultivated, or the *grana fina*, termed also *mesteque*, from the name of a Mexican province. The first is smaller, and covered with a cottony down, which increases its bulk with a matter useless in dyeing; it yields, therefore, in equal weight, much less color, and is of inferior price to that of the fine cochineal. But these disadvantages are compensated in some measure to the growers by its being reared more easily, and

less expensively; partly by the effect of its down, which enables it better to resist rains and storms.

The wild cochineal, when it is bred upon the field nopal, loses in part the tenacity and quantity of its cotton, and acquires a size double of what it has on the wild opuntias. It may, therefore, be hoped that it will be improved by persevering care in the rearing of it, when it will approach more and more to fine cochineal.

The fine cochineal, when well dried and well preserved, should have a gray color, bordering on purple. The gray is owing to the powder, which naturally covers it, and of which a little adheres; as also to a waxy fat. The purple shade arises from the color extracted by the water in which they were killed. It is wrinkled with parallel furrows across its back, which are intersected in the middle by a longitudinal one; hence, when viewed by a magnifier, or even a sharp naked eye, especially after being swollen by soaking for a little in water, it is easily distinguished from the factitious, smooth, glistening, black grains, of no value, called East India cochineal, with which it is often shamefully adulterated by certain London merchants. The genuine cochineal has the shape of an egg, bisected through its long axis, or of a tortoise, being rounded like a shield upon the back, flat upon the belly, and without wings.

These female insects are gathered off the leaves of the nopal plant, after it has ripened its fruit, a few only being left for brood, and are killed, either by a momentary immersion in boiling water, by drying upon heated plates, or in ovens: the last become of an ash-gray color, constituting the *silver* cochineal, or *jaspeada;* the second are blackish, called *negra,* and are most esteemed, being probably driest; the first are reddish brown, and reckoned inferior to the other two. The dry cochineal being sifted, the dust, with the imperfect insects and fragments which pass through, are sold under the name of *granillo.*

Cochineal keeps for a long time in a dry place. Hellot says that he has tried some 130 years old, which produced the same effect as new cochineal.

We are indebted to MM. Pelletier and Caventou for a chemical investigation of cochineal, in which its coloring matter was skilfully eliminated.

Purified sulphuric ether acquired by digestion with it a golden yellow color, amounting by Dr. John to one tenth of the weight of the insect. This infusion left, on evaporation, a fatty wax of the same color.

Cochineal, exhausted by ether, was treated with alcohol at 40° B. After 30 infusions in the digester of M. Chevreul, the cochineal continued to retain color, although the alcohol had ceased to have any effect on it. The first alcoholic liquors were of a red verging on yellow. On cooling, they let fall a granular matter. By spontaneous evaporation, this matter, of a fine red color, separated, assuming more of the crystalline appearance. These species of crystals dissolved entirely in water, which they tinged of a yellowish-red.

This matter has a very brilliant purple-red color; it adheres strongly to the sides of the vessels; it has a granular and somewhat crystalline aspect, very different, however, from those compound crystals alluded to above; it is not altered by the air, nor does it sensibly attract moisture. Exposed to the action of heat, it melts at about the fiftieth degree centigrade (122° Fahr.). At a higher temperature it swells up, and is decomposed with the production of carbureted hydrogen, much oil, and a small quantity of water, very slightly acidulous. No trace of ammonia was found in these products.

The coloring principle of cochineal is very soluble in water. By evaporation, the liquid assumes the appearance of sirup, but never yields crystals. It requires of this matter a portion almost imponderable to give a perceptible tinge of bright purplish red to a large body of water. Alcohol dissolves this coloring substance, but, as we have already stated, the more highly it is rectified the less of it does it dissolve. Sulphuric ether does not dissolve the coloring principle of cochineal; but weak acids do, possibly owing to their water of dilution. No acid precipitates it in its pure state. This coloring principle, however, appears to be precipitable by all the acids, when it is accompanied by the animal matter of the cochineal.

The affinity of alumina for the coloring matter is very remarkable. When that earth, newly precipitated, is put into a watery solution of the coloring principle, this is immediately seized by the alumina. The water becomes colorless, and a fine red lake is obtained, if we operate at the temperature of the atmosphere; but if the liquor has been hot, the color passes to crimson, and the shade becomes more and more violet, according to the elevation of the temperature, and the continuance of the ebullition.

The salts of tin exercise upon the coloring matter of cochineal a remarkable action. The muriatic protoxyde of tin forms a very abundant violet precipitate in the liquid. This precipitate verges on crimson, if the salt contains an excess of acid. The muriatic deutoxyde of tin produces no precipitate, but changes the color to scarlet-red. If gelatinous alumina be now added, we obtain a fine red precipitate, which does not pass to crimson by boiling.

To this coloring principle the name *carminium* has been given, because it forms the basis of the pigment called carmine.

The process followed in Germany for making carmine, which consists in pouring a certain quantity of solution of alum into a decoction of cochineal, is the most simple of all, and affords an explanation of the formation of carmine, which is merely the carminium and the animal matter precipitated by the excess of acid in the salt, which has taken down with it a small quantity of alumina; though it appears that alumina ought not to be regarded as essential to the formation of carmine. In fact, by another process, called by the name of Madame Cenette of Amsterdam, the carmine is thrown down, by pouring into the decoction of cochineal a certain quantity of the binoxalate of potash. When carbonate of soda is added, then carminated lake also falls down. That carmine is a triple compound of animal matter, carminium, and an acid, appears from the circumstance that liquors which have afforded their carmine, when a somewhat strong acid is poured into them, yield a new formation of carmine by the precipitation of the last portions of the animal matter. But whenever the whole animal matter is thrown down, the decoctions, although still much charged with the coloring principle, can afford no more carmine. Such decoctions may be usefully employed to make carminated lakes, saturating the acid with a slight excess of alkali, and adding gelatinous alumina. The precipitates obtained on adding acids to the alkaline decoctions of cochineal, are therefore true carmines, since they do not contain alumina; but the small quantity of alumina which is thrown down by alum in the manufacture of carmine, augments its bulk and weight. It gives, besides, a greater lustre to the color, even though diluting and weakening it a little.

The carmines found in the shops of Paris were analyzed, and yielded the same products. They are decomposed by the action of heat, with the diffusion at first of a very strong smell of burning animal matter, and then of sulphur. A white powder remained, amounting to about one tenth of the matter employed, and which was found to be alumina. Other quantities of carmine were treated with a solution of caustic potash, which completely dissolved them, with the exception of a beautiful red powder, not acted on by potash and concentrated acids, and which was recognised to be red sulphuret of mercury or vermilion. This matter, evidently foreign to the carmine, appears to have been added in order to increase its weight.

The preceding observations and experiments seem calculated to throw some light on the art of dyeing scarlet and crimson. The former is effected by employing a cochineal bath, to which there have been added, in determinate proportions, acidulous tartrate of potash, and nitro-muriatic deutoxyde of tin. The effect of these two salts is now well known. The former, in consequence of its excess of acid, tends to redden the color, and to precipitate it along with the animal matter; the latter acts in the same manner, at first by its excess of acid, then by the oxyde of tin which falls down also with the carmine and animal matter, and is fixed on the wool, with which it has of itself a strong tendency to combine. MM. Pelletier and Caventou remark, that " to abtain a beautiful shade, the muriate of tin ought to be entirely at the maximum of oxydizement; and it is in reality in this state that it must exist in the solution of tin prepared according to the proportions prescribed in M. Berthollet's treatise on dyeing."

We hence see why, in dyeing scarlet, the employment of alum is carefully avoided, as this salt tends to convert the shade to a crimson. The presence of an alkali would seem less to be feared. The alkali would occasion, no doubt, a crimson-colored bath; but it would be easy in this case to restore the color, by using a large quantity of tartar. We should, therefore, procure the advantage of having a bath better charged with coloring matter and animal substance. It is for experience on the large scale to determine this point. As to the earthy salts, they must be carefully avoided; and if the waters be selenitish, it would be a reason for adding a little alkali.

To obtain crimson, it is sufficient, as we know, to add alum to the cochineal bath, or to boil the scarlet cloth in alum water. It is also proper to diminish the dose of the salt of tin, since it is found to counteract the action of the alum.

The alkalis ought to be rejected as a means of changing scarlet to crimson. In fact, crimsons by this process cannot be permanent colors, as they pass into reds by the action of acids.

According to M. Von Grotthuss, carmine may be deprived of its golden shade by ammonia, and subsequent treatment with acetic acid and alcohol. Since this fact was made known, M. Herschel, color maker at Halle, has prepared a most beautiful carmine.

The officers of Her Majesty's Customs have lately detected a system of adulterating cochineal, which has been practised for many years upon a prodigious scale by a mercantile house in London. I have analyzed about 100 samples of such cochineal, from which it appears that the genuine article is moistened with gum-water, agitated in a box or

leather bag, first, with sulphate of baryta in fine powder, afterwards with bone or ivory black, to give it the appearance of *negra* cochineal, and then dried. By this means about 12 per cent. of the worthless heavy spar is sold at the price of cochineal, to the enrichment of the sophisticators, and the disgrace and injury of British trade and manufactures.

The specific gravity of genuine cochineal is 1·25; that of the cochineal loaded with the barytic sulphate 1·35. It was taken in oil of turpentine and reduced to water as unity, because the waxy fat of the insects prevents the intimate contact of the latter liquid with them, and the ready expulsion of air from their wrinkled surface. They are not at all acted upon by the oil, but are rapidly altered by water, especially when they have been gummed and barytified.

The quantities of cochineal imported into the United Kingdom in the following years were : —

	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
Lbs.	320,722	258,032	288,456	316,589	244,371	388,478	359,381	410,387	418,320

The quantities re-exported were : —

	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
	145,756	158,109	153,738	100,059	168,329	138,270	130,732	265,490	352,023

Humboldt states that so long ago as the year 1736, there was imported into Europe from South America cochineal to the value of 15 millions of francs. Its high price had for a long time induced dyers to look out for cheaper substitutes in dyeing red, and since science has introduced so many improvements in tinctorial processes, both madder and lac have been made to supersede cochineal to a very great extent. Its price has, in consequence of this substitution, as well as from more successful modes of cultivation, fallen very greatly of late years. At present it is only 7s. per lb. in London. See SCARLET DYEING.

COCOA, STEARINE, and ELAINE. Mr. Soames obtained a patent in September, 1829, for making these useful articles, by the following process : —

He takes the substance called cocoa-nut oil, in the state of lard, in which it is imported into this country, and submits it to a strong hydraulic pressure, having made it up in small packages, 3 or 4 inches wide, 2 feet long, and 1 or 1½ inches thick. These packages are formed by first wrapping up the said substance in a strong linen cloth, of close texture, and then in an outward wrapper of strong sail cloth. The packages are to be placed side by side, in single rows, between the plates of the press, allowing a small space between the packages for the escape of the *elaine*.

The temperature at which the pressure is begun, should be from about 50 to 55 degrees, or in summer as nearly at this pitch as can be obtained, and the packages of the said substance intended for pressure, should be exposed for several hours previously to about the same temperature. When the packages will no longer yield their oil or elaine freely at this temperature, it is to be gradually raised; but it must at no time exceed 65 degrees, and the lower the temperature at which the separation can be effected, the better will be the quality of the oil expressed.

When the packages are sufficiently pressed, that is, when they will give out no more oil, or yield it only in drops at long intervals, the residuum in them is to be taken out and cleansed and purified, which is done by melting it in a well-tinned copper vessel, which is fixed in an outer vessel, having a vacant space between, closed at the top, into which steam is admitted, and the heat is kept up moderately for a sufficient time to allow the impurities to subside; but if a still higher degree of purity is required, it is necessary to pass it through filters of thick flannel lined with blotting paper.

Having been thus cleansed or purified, it is fit for the manufacture of candles, which are made by the ordinary process used in making mould tallow candles. Having thus disposed of the stearine, or what is called the first product, he proceeds with the elaine or oil expressed from it, and which he calls the second product, as follows: that is to say, he purifies it by an admixture, according to the degree of its apparent foulness, of from 1 to 2 per cent. by weight of the sulphuric acid of commerce, of about 1·80 specific gravity, diluted with six times its weight of water. The whole is then to be violently agitated by mechanical means, and he prefers for this purpose the use of a vessel constructed on the principle of a common barrel churn. When sufficiently agitated, it will have a dirty whitish appearance, and is then to be d awn off into another vessel, in which it is to be allowed to settle, and any scum that rises is to be carefully taken off. In a day or two the impurities will be deposited at the bottom of the oil, which will then become clear, or nearly so, and it is to be filtered through a thick woollen cloth, after which it will be fit for burning in ordinary lamps and for other uses.

The process of separating the elaine from the stearine, by pressure, in manner aforesaid, had never before been applied to the substance called cocoa-nut oil, and consequently no product had heretofore been obtained thereby from that substance, fit for being manufactured into candles in the ordinary way, or for being refined by any of the usual

odes, so as to burn in ordinary lamps, both which objects are obtained by this method
of preparing or manufacturing the said substance.

Candles well made from the above material are a very superior article. The light
roduced is more brilliant than from the same sized candle made of tallow; the flame is
erfectly colorless, and the wick remains free from cinder, or any degree of foulness du-
ng combustion.

COFFEE. The coffee is the seed of a tree of the family *rubiaceæ*, and belongs to the
entandria monogynia of Linnæus. There are several species of the genus, but the only
ne cultivated is the *Coffea Arabica*, a native of Upper Ethiopia and Arabia Felix. It
ises to the height of 15 or 20 feet; its trunk sends forth opposite branches in pairs above
id at right angles to each other; the leaves resemble those of the common laurel, al-
ough not so dry and thick. From the angle of the leaf-stalks small groups of white
owers issue, which are like those of the Spanish jasmine. These flowers fade very soon,
id are replaced by a kind of fruit not unlike a cherry, which contains a yellow glairy
iid, enveloping two small seeds or berries convex upon one side, flat and furrowed upon
e other in the direction of the long axis. These seeds are of a horny or cartilaginous
iture; they are glued together, each being surrounded with a peculiar coriaceous mem-
rane. They constitute the coffee of commerce.

It was not till towards the end of the 15th century that the coffee-tree began to be cul-
vated in Arabia. Historians usually ascribe the discovery of the use of coffee as a be-
erage to the superior of a monastery there, who, desirous of preventing the monks from
eeping at their nocturnal services, made them drink the infusion of coffee upon the re-
ort of shepherds, who pretended that their flocks were more lively after browsing on the
uit of that plant. The use of coffee was soon rapidly spread, but it encountered much
pposition on the part of the Turkish government, and became the occasion of public as-
emblies. Under the reign of Amurath III. the mufti procured a law to shut all the cof-
e-houses, and this act of suppression was renewed under the minority of Mahomet IV.
was not till 1554, under Solyman the Great, that the drinking of coffee was accredited in
onstantinople; and a century elapsed before it was known in London and Paris. Soly-
an Aga introduced its use into the latter city. in 1669, and in 1672 an Armenian estab-
shed the first *café* at the fair of Saint Germain.

When coffee became somewhat of a necessary of life, from the influence of habit
mong the people, all the European powers who had colonies between the tropics, pro-
eted to form plantations of coffee-trees in them. The Dutch were the first who trans-
orted the coffee plant from Moka to Batavia, and from Batavia to Amsterdam. In
714 the magistrates of that city sent a root to Louis XIV., which he caused to be
lanted in the Jardin du Roi. This became the parent stock of all the French coffee plan-
ations in Martinique.

The most extensive culture of coffee is still in Arabia Felix, and principally in the
ingdom of Yemen, towards the cantons of Aden and Moka. Although these countries
re very hot in the plains, they possess mountains where the air is mild. The coffee is
enerally grown half way up on their slopes. When cultivated on the lower grounds it
s always surrounded by large trees which shelter it from the torrid sun, and prevent its
ruit from withering before their maturity. The harvest is gathered at three periods; the
most considerable occurs in May, when the reapers begin by spreading cloths under the
rees, then shaking the branches strongly, so as to make the fruit drop, which they collect,
nd expose upon mats to dry. They then pass over the dried berries a very heavy roller,
o break the envelops, which are afterwards winnowed away with a fan. The interior
ean is again dried before being laid up in store.

In Demarara, Berbice, and some of our West India islands, where much good coffee
s now raised, a different mode of treating the pulpy fruit and curing the beans is
dopted. When the cherry-looking berry has assumed a deep-red color it is gathered,
nd immediately subjected to the operations of a mill composed of two wooden rollers,
urnished with iron plates, which revolve near a third fixed roller called the *chops*.
The berries are fed into a hopper above the rollers, and falling down between them and
the chops, they are stripped of their outer skin and pulp, while the twin beans are se-
parated from each other. These beans then fall upon a sieve, which allows the skin and
the pulp to pass through, while the hard beans accumulate and are progressively slid
over the edge into baskets. They are next steeped for a night in water, thoroughly
washed in the morning, and afterwards dried in the sun. They are now ready for the
peeling mill, a wooden edge wheel turned vertically by a horse yoked to the extremity of
its horizontal axis. In travelling over the coffee, it bursts and detaches the coriaceous
or parchment-like skin which surrounds each hemispherical bean. It is then freed from
the membranes by a winnowing machine, in which four pieces of tin made fast to an axle
are caused to revolve with great velocity. Corn fanners would answer better than this
rude instrument of negro invention. The coffee is finally spread upon mats or tables,
picked clean, and packed up for shipment.

The most highly esteemed coffee is that of Moka. It has a smaller and a rounder bean; a more agreeable taste and smell than any other. Its color is yellow. Next to it in European reputation are the Martinique and Bourbon coffees; the former is larger than the Arabian, and more oblong; it is rounded at the ends; its color is greenish, and it preserves almost always a silver gray pellicle, which comes off in the roasting. The Bourbon coffee approaches nearest to the Moka, from which it originally sprung. The Saint Domingo coffee has its two extremities pointed, and is much less esteemed than the preceding.

The coffee-tree flourishes in hilly districts, where its root can be kept dry, while its leaves are refreshed with frequent showers. Rocky ground, with rich decomposed mould in the fissures, agrees best with it. Though it would grow, as we have said, to the height of 15 or 20 feet, yet it is usually kept down by pruning to that of five feet, for increasing the production of the fruit, as well as for the convenience of cropping. It begins to yield fruit the third year, but is not in full bearing till the fifth, does not thrive beyond the twenty-fifth, and is useless in general at the thirtieth. In the coffee husbandry, the plants should be placed eight feet apart, as the trees throw out extensive horizontal branches, and in holes ten or twelve feet deep, to secure a constant supply of moisture.

Coffee has been analyzed by a great many chemists, with considerable diversity of results. The best analysis perhaps is that of Schrader. He found that the raw beans distilled with water in a retort communicated to it their flavor and rendered it turbid, whence they seem to contain some volatile oil. On reboiling the beans, filtering, and evaporating the liquor to a sirup, adding a little alcohol till no more matter was precipitated, and then evaporating to dryness, he obtained 17·58 per cent. of a yellowish-brown transparent extract, which constitutes the characteristic part of coffee, though it is not in that state the pure proximate principle called *cafeine*. Its most remarkable reaction is its producing, with both the protoxyde and the peroxyde salts of iron, a fine grass green color, while a dark green precipitate falls, which re-dissolves when an acid is poured into the liquor. It produces on the solution of the salts of copper scarcely any effect, till an alkali be added, when a very beautiful green color is produced, which may be employed in painting. Coffee beans contain also a resin, and a fatty substance somewhat like suet. According to Robiquet, ether extracts from coffee beans nearly 10 per cent. of resin and fat, but he probably exaggerates the amount. The peculiar substance cafeine contained in the above extract is crystallizable. It is remarkable in regard to composition, that after urea and the uric acid, it is among organic products the richest in azote. It was discovered and described in 1820 by Runge. It does not possess alkaline properties. Pfaff obtained only 90 grains of cafeine from six pounds of coffee beans. There is also an acid in raw coffee, to which the name of *cafeic acid* has been given. When distilled to dryness and decomposed, it has the smell of roasted coffee.

Coffee undergoes important changes in the process of roasting. When it is roasted to a yellowish brown it loses, according to Cadet, 12½ per cent. of its weight, and is in this state difficult to grind. When roasted to a chestnut brown it loses 18 per cent., and when it becomes entirely black, though not at all carbonized, it has lost 23 per cent. Schrader has analyzed roasted coffee comparatively with raw coffee, and he found in the first 12½ per cent. of an extract of coffee, soluble in water and alcohol, which possesses nearly the properties of the extract of the raw coffee, although it has a deeper brown color, and softens more readily in the air. He found also 10·4 of a blackish brown gum; 5·7 of an oxygenated extract, or rather *apo'hème*, soluble in alcohol, insoluble in water; 2 of a fatty substance and resin; 69 of burnt vegetable fibre, insoluble. On distilling roasted coffee with water, Schrader obtained a product which contained the aromatic principle of coffee; it reddened litmus paper, and exhaled a strong and agreeable odor of roasted coffee. If we roast coffee in a retort, the first portions of the aromatic principle of coffee condense into a yellow liquid in the receiver; and these may be added to the coffee roasted in the common way, from which this matter has been expelled and dissipated in the air.

Chenevix affirmed that by the roasting of coffee a certain quantity of tannin possessing the property of precipitating gelatin is generated. Cadet made the same observation, and found, moreover, that the tannin was most abundant in the lightly roasted coffee, and that there was nearly none of it in coffee highly roasted. Payssé and Schrader, on the contrary, state that solution of gelatin does not precipitate either the decoction of roasted coffee or the alcoholic extract of this coffee. Runge likewise asserts that he could obtain no precipitate with gelatin; but he says that albumen precipitates from the decoction of roasted coffee the same kind of tannin as is precipitated from raw coffee by the acetate of lead, and set free from the lead by sulphureted hydrogen. With these results my own experiments agree. Gelatin certainly does not disturb clear infusion of roasted coffee, but the salts of iron blacken it.

ideavored to roast separately the different principles of coffee, but none of
the aromatic odor of roasted coffee except the horny fibrous matter. He
cludes that this substance contributes mainly to the characteristic taste of
, which cannot be imitated by any other vegetable matter, and which, as we
ould be ascribed chiefly to the altered cafeic acid. According to Garot, we
he cafeine without alteration from roasted coffee by precipitating its decoc-
etate of lead, treating the washed precipitate with sulphureted hydrogen,
ng the liquid product to dryness.
rs, much ingenuity has been expended in contriving various forms of appa-
ing infusions of coffee for the table. I have tried most of them, and find,
: so good as a *cafetière à la Belloy*, the coffee *biggin*, with the perforated tin-
, especially when the filtered liquor is kept simmering in a close vessel, set
r steam pan. The useful and agreeable matter in coffee is very soluble: it
h the first waters of infusion, and needs no boiling.
ffee rightly we should keep in view the proper objects of this process, which
) its aroma, and destroy its toughness, so that it may be readily ground to
) much heat destroys those principles which we should wish to preserve, and
w ones which have nothing in common with the first, but add a disagreea-
iatic taste and smell. If, on the other hand, the rawness or greenness is
)y an adequate heat, it masks the flavor of the bean, and injures the bev-
ith it. When well roasted in the sheet-iron cylinders set to revolve over a
have a uniform chocolate color, a point readily hit by experienced roasters,
iage the business very well for the principal coffee-dealers both of London
far as my judgment can determine. The development of the proper aroma
by which coffee-roasters frequently regulate their operations. When it loses
per cent. of its weight, coffee is sure to be injured. It should never be
mediately before infusion.
arbonized pitcoal. See CHARCOAL; and PITCOAL at the end.
[AR OF VITRIOL (*Rouge d'Angleterre*, Fr.; *Rothes Eisenoxyd*, Germ.)
red peroxyde of iron, produced by calcining sulphate of iron with a strong
ig the resulting mass, and elutriating it into an impalpable powder. A bet-
iking it so as to complete the separation of the acid, is to mix 100 parts of
phate of iron with 42 of common salt, to calcine the mixture, wash away
sulphate of soda, and levigate the residuum. The sulphuric acid in this
e chlorine of the salt in the form of muriatic acid gas, and saturates its
produced by the chemical reaction; whence an oxyde will be obtained free
ch superior to what is commonly found in the shops. The best sort of pol-
, called *jewellers' red rouge* or plate powder, is the precipitated oxyde of iron
adding solution of soda to solution of copperas, washing, drying, and cal-
vder in shallow vessels with a gentle heat, till it assumes a deep brown red
ion.
NY, black rosin, the solid residuum of the distillation of turpentine, when
been worked off.
G MATTER. (*Matière colorante*, Fr.; *Farbstoff*, Germ.) See DYEING,
e-stuffs and pigments.
UM, a peculiar metal extracted from a rare mineral brought from Haddam,
t. It is also called Tantalium, from the mineral *tantalite* and *yttro-tantalite*,
ien. It has hitherto no application to the arts. It combines with two suc-
of oxygen; by the second it becomes an acid.
a variety of cabbage, the *brassica oleracea*, whose seeds afford, by pressure,
mployed in France and Belgium for burning in lamps, and for many other
his plant requires a rich but light soil; it does not succeed upon either sandy
s. The ground for it must be deeply ploughed and well dunged. It should
ly, and be afterward replanted in a richly-manured field. In October it is
out in beds, 15 or 18 inches apart. Colza may also be sowed in furrows 8
sunder.
i has been just cropped for wheat is that usually destined to colza; it may
;ed with advantage. The harvest takes place in July, with the sickle, a
ie seeds are completely ripe, lest they should drop off. As the seed is pro-
however, only in proportion to its ripeness, the cut plants are allowed to
· maturation, by laying them in heaps under airy sheds, or placing them in
hatching it with straw.
;e-stalks are thrashed with flails, the seeds are winnowed, sifted, spread out
lry; then packed away in sacks, in order to be subjected to the oil-mill at
of winter. The oil-cake is a very agreeable food to cattle, and serves to
It is reckoned to defray the cost of the mill.
verishes the soil very much, as do, indeed, all the plants cultivated for the

sake of their oleaginous seeds. It must not, therefore, be come back upon again for six years, if fine crops be desired. The double ploughing which it requires effectually cleans the ground. See OILS, UNCTUOUS.

COMB, the name of an instrument made of a thin plate either plane or curved of wood, horn, tortoise-shell, ivory, bone, or metal, cut out upon one or both of its sides or edges, into a series of somewhat long teeth, not far apart; which is employed for disentangling, laying parallel and smooth the hairs of man, horses, or other animals.

A thin steel saw bow, mounted in an iron or wooden handle, is the implement used by the comb-maker to cut the bone, ivory, and wood into slices of from a twelfth to a quarter of an inch thick, and of a size suitable to that of the comb. The pieces of tortoise-shell as found in commerce are never flat, or, indeed, of any regular curvature, such as the comb must have. They are therefore steeped in boiling water sufficiently long to soften them, and set to cool in a press between iron or brass moulds, which impart to them the desired form which they preserve after cooling. After receiving their outline shape and curvature, by proper flat files or fine rasps, the place of the teeth is marked with a triangular file, and then the teeth themselves are cut out with a double saw, composed of two thin slips of tempered steel, such as the main-spring of a watch, notched with very fine sharp teeth. These slips are mounted in a wooden or iron stock or handle, in which they may be placed at different distances, to suit the width of the comb-teeth. A comb-maker, however, well provided in tools, has an assortment of double saws set at every ordinary with. The two slips of this saw have their teeth in different planes, so that when it begins to cut, the most prominent slip alone acts, and when the teeth of this one have fairly entered into the comb, the other parallel blade begins to saw. The workman, meanwhile, has fixed the plate of tortoise-shell or ivory between the flat jaws of two pieces of wood, like a vice made fast to a bench, so that the comb intended to be cut is placed at an angle of 45° with the horizon. He now saws perpendicularly, forming two teeth at a time, proceeding truly in the direction of the first tracing.

A much better mode of making combs is to fix upon a shaft or arbor in a lathe a series of circular saws, with intervening brass washers or discs to keep them at suitable distances; to set in a frame like a vice, in front of these saws, the piece of ivory or horn to be cut; and to press it forward upon the saws at an angle of 45 degrees, by means of a regulated screw motion. When the teeth are thus cut, they are smoothed and polished with files, and by rubbing with pumice-stone and tripoli.

Mr. Bundy, of Camden Town, obtained a patent so long ago as 1796, for an apparatus of that kind, which had an additional arbor fitted with a series of circular saws, or rather files, for sharpening the points of the comb-teeth.

More recently, Mr. Lyne has invented a machine in which, by means of pressure, two combs are cut out at once with chisels from any tough material, such as horn or tortoise-shell, somewhat softened at the moment by the application of a heated iron to it. The piece of horn is made fast to a carriage, which is moved forward by means of a screw until it comes under the action of a ratchet-wheel, toothed upon a part of its circumference. The teeth of this wheel bring a lever into action, furnished with a chisel or knife, which cuts out a double comb from the flat piece, the teeth of which combs are opposite to each other. By this means, no part of the substance is lost, as in sawing out combs. The same carriage may be used, also, to bear a piece of ivory in the hard state toward a circular saw, on the principles above explained, with such precision, that from 80 to 100 teeth can be formed in the space of one inch by a proper disposition of the tool.

Bullocks' horns, after the tips are sawed off, are roasted in the flame of a wood fire, till they are sufficiently softened; when they are slit up, pressed in a machine between two iron plates, and then plunged into a trough of cold water, whereby they are hardened. A paste of quicklime, litharge, and water is used to stain the horn to resemble tortoise-shell. See HORN.

COMBINATION (Combinaison, Fr.; Verbindung, Germ.); a chemical term which denotes the intimate union of dissimilar particles of matter, into a homogeneous-looking compound, possessed of properties generally different from those of the separate constituents.

COMBUSTIBLE (Eng. and Fr.; Brennstoff, Germ.); any substance which, exposed in the air to a certain temperature, consumes spontaneously with the emission of heat and light. All such combustibles as are cheap enough for common use go under the name of Fuel; which see. Every combustible requires a peculiar pitch of temperature to be kindled, called its accendible point. Thus phosphorus, sulphur, hydrogen, carbureted hydrogen, carbon, each takes fire at successively higher heats.

COMBUSTION (Eng. and Fr.; Verbrennung, Germ.) results in common cases from the mutual chemical reaction of the combustible, and the oxygen of the atmosphere,

compound is formed; the heat and light evolved being most probably
rapid motions of the particles during the progress of this combination.
COLORS. If the effects of the coloring particles did not vary
e combinations which they form, and the actions exercised upon them by
bstances present in a dyeing bath, we might determine with precision
ought to result from the mixture of any two colors, or of the ingredients
colors separately. Though the chemical action of the mordants, and of
e dye-bath often changes the results, yet theory may always predict them
degree. It is not the color appropriate to the dye-stuffs which is to be
he constituent part of compound colors, but that which they must assume
mordant and dye-bath. Our attention ought therefore to be directed
he operation of the chemical agents employed.
are of blue and yellow dyes produces green. D'Ambourney, indeed,
s extracted a fast green from the fermented juice of the berries of the
mæus fragula), but no dyer would trust to such a color.
are of red and blue produces violet, purple, *columbine* (dove-color),
h, lilach, mallow, and a great many other shades, determined by the nature
e red and blue dye-stuffs, as well as their relative proportions in the

ure of red and yellow produces orange, *mordoré*, cinnamon, *coquelicot*,
; with the addition of blue, olives of various shades; and with duns in-
s, chestnut, snuff, musk, and other tints.
f the lighter kinds constitute grays; and, mixed with other colors, pro-
(marroons), coffees, damascenes. For further details upon this sub-
to PRINTING, DYEING, as also the individual colors in their alphabetical

. The name given by architects to a compact mass of pebbles, sand,
nted together, in order to form the foundations of buildings. Semple
est proportions are 80 parts of pebbles, each about 7 or 8 ounces in
ts sharp river sand, and 10 of good lime; the last is to be mixed with
nish consistence, and grouted in. It has been found that Thames ballast,
he bed of the river, consists nearly of 2 parts of pebbles to 1 of sand, and
ers exceedingly well for making concrete; with from one seventh to one
lime. The best mode of making concrete, according to Mr. Godwin,
lime, previously ground, with the ballast in a dry state; sufficient water
over it to effect a perfect mixture, after which it should be turned over at
h shovels, or oftener; then put into barrows, and wheeled away for use
is generally found advisable to employ two sets of men to perform this
three in each set; one man to fetch the water, &c., while the other two
mixture to the second set, and they, repeating the process, turn over the
barrow-men. After being put into the barrows, it should at once be
lanks, so raised as to give it a fall of some yards, and thrown into the
which means the particles are driven closer together, and greater solidity
whole mass. Soon after being thrown in, the mixture is observed usually
motion, and much heat is evolved with a copious emission of vapor.
ad of concrete in the fall, spreading over the ground, will form generally
om 7 to 9 inches thick, which should be allowed to set before throwing in

thod of making concrete, is first to cover the foundation with a certain
ter, and then to throw in the dry mixture of ballast and lime. It is next
elled with shovels; after which more water is pumped in, and the operation
The former method is undoubtedly preferable.
es it has been found necessary to mix the ingredients in a pug-mill, as in
c. for bricks. For the preparation of a concrete foundation, as the harden-
rapid, no more water should be used than is absolutely necessary to effect
ure of the ingredients. Hot water accelerates the induration. There is
of contraction in volume in the concrete, in reference to the bulk of its
To form a cubical yard of concrete, about 30 feet cube of ballast and 3½
round lime must be employed, with a sufficient quantity of water.
TION (Eng. and Fr.; *Gefrierung*, Germ.); the act of freezing liquids.
are supplied by chemistry of effecting or promoting this process, but they
ate any peculiar art or manufacture. See ICE-HOUSE.
OF FLUIDS. In Mr. Derosnes's method, the cooling agents employed
of atmospheric air, and warm water of the same or nearly the same
that of the vapors which are to be operated upon.
presents merely a diagram of the general features of an apparatus con-

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structed upon the principles proposed to be employed, which will serve to explain the nature of this improvement.

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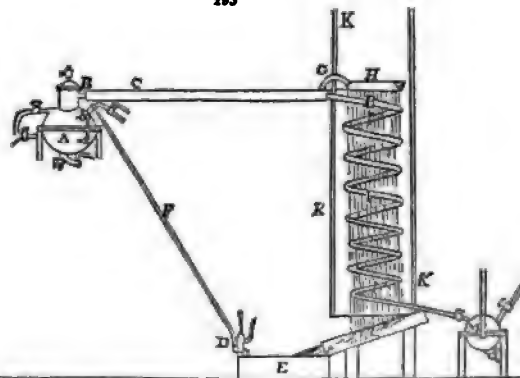
Let A be the source of the vapors, or the vessel, boiler, alembic, or closed pan that contains the liquid or sirup to be evaporated or concentrated. The pipe B, through which the vapor passes as it rises in the boiler, is surrounded by another tube C, of larger diameter, closed at both ends. A pump D, draws from the reservoir E. warm water, which water has been heated by its previous and continual passage through the apparatus in contact with the surface of the vapor pipes.

This pump forces the water by the pipe F, into the annular space or chamber between the pipes B and C, in which chamber, by its immediate contact with the pipe B, it acquires the temperature of the vapors intended to be refrigerated. The pipe G conveys the water from the pipe C, into the annular colander or sieve H, which has a multitude of small holes pierced through its under part, and whence the warm water descends in the form of a continued shower of rain. To the end of the pipe B, a distiller's worm I I, is connected, which is placed beneath the colander H. The entire length of the worm-pipe should be bound round with linen or cotton cloth, as a conductor of the heat, which cloth will be continually moistened by the rain in its descent from the colander. As this water has been heated in passing along the tube C, the shower of rain descending from the colander will be at a higher temperature than that of the atmosphere, and, consequently, by heating the surrounding air as it descends, a considerable upward draft will be produced through the coils of the worm-pipe.

If the colander and the worm-pipe are enclosed within a chimney or upright tube, as K K, open at top and bottom, a current of ascending air will be produced within it by the descending shower of hot water, similar in effect to that which would be produced in a chimney communicating with a furnace, or to that of the burner of an argand lamp. Consequently, it will be perceived that in opposition to the descending rain, a strong upward current of air will blow through that part of the cylinder K K, which is beneath the colander. When the air first enters the lower aperture of the chimney or tube K, it is of the same temperature and moisture as the external atmosphere; but in its passage up the tube it meets with a warmer and damper atmosphere, caused by the heat given out from the hot fluid continually passing through the pipes, and by the hot shower of rain, and also by the steam evolved from the surfaces of the coils of the worm, which are continually wetted by the descending rain, the evaporation being considerably augmented by the cloth bound round the worm-pipe, retaining the water as it descends in drops from coil to coil.

The atmosphere within the tube being of a higher temperature than without, a current of air constantly ascends and escapes at the upper aperture K, and its place is supplied by fresh air from the surrounding atmosphere, entering the tube below. The fresh air thus admitted at the bottom of the tube, being cold and dry, will be suited to take up the heat and moisture within, because the water within the tube, being in a state of dispersion as rain, presents to the air many points, or a very extended surface, and also because it is of a higher temperature than the air; and, besides, cold dry air is continually renewed, and a source of warmth is furnished by the latent caloric to the steam as fast as it is evolved. Thus a portion of the descending rain, or water, is evaporated, and the effect of this evaporation is to subtract caloric not only from the water held in contact with the coils of the worm-pipe by the cloth enveloping it, but also from the hot vapors which pass through the worm. This process of evaporation has, therefore, a cooling power, which is but slight in the lower part of the chimney or tube K; because the temperature of the water, or rain, and of the worm, at this part, is of a lower temperature; but its refrigerating power increases as it rises towards the colander, and there it acquires its maximum of intensity, so that at any point between the lower aperture of the cylinder and the colander, the current of air is always a little cooler than the atmosphere of the region through which it passes (that is, at its maximum); and in passing this region of higher temperature, it is not only put in equili

brium of temperature, but also made to take up an additional quantity of aqueous vapors, which equalizes the new temperature it acquires with its capacity of saturation. The cooling caused by the evaporation acts in an incessant and progressive manner from the lower aperture of the cylinder to the under side of the colander; and this cooling not only acts as an agent of the evaporation which the current of air cools, but it refrigerates also, because it becomes warmed in abstracting caloric from the vapors or liquids passing through the worm; and this refrigeration acts also incessantly and progressively from the lower part of the tube or chimney to the colander.

The patentee states, in conclusion, that "the velocity or force of the current of air that passes through the chimney or tube κ, can be accelerated by artificial means, either by conducting the air and vapor passing from the upper aperture of the cylinder into the chimney or flues of a furnace, or by means of a revolving, forcing, or exhausting fan, or ventilator, or any other contrivance which will produce an increased current of air, but which is not necessary to be particularly described, as I only wish to explain the principles of a simple apparatus, constructed in any convenient form; and I would remark, that the area of the lower aperture through which the air is introduced into the chimney or tube κ, and also the area of the upper aperture, or that through which it passes to the atmosphere, should be in accordance with the effect intended to be obtained.

"It is further to be remarked, that in order to obtain from this apparatus the best effect, the velocity of the current of air must be itself a maximum; and as the speed or velocity of the current of air is owing to and determined by the excess of the temperature of the descending water, or rain, and of the coils of the worm to that of the exterior atmosphere, it ensues that the temperature of the water, or rain, must be a maximum. But this excess of temperature is a maximum only when the source of the rain is at the same temperature as the vapors to be condensed: if less warm, it would attract less air; or, if warmer, it would augment the temperature of the vapors intended to be condensed. Consequently, the shower of water employed in the tube κ, as the agent for cooling, bestows its maximum of effect when it is as warm as the vapors to be condensed; therefore, I may express this proposition, viz., ' That in refrigerating with water, less of it may be expended when it is warm than when it is cold, and that the least quantity of water will be evaporated when it is as warm as the aqueous or spirituous vapors upon which it is to operate.'

"This proposition may appear strange, nevertheless it is conformable to the laws of nature; and appears only strange, because until now warm water has not been employed with currents of air for refrigerating.

"Hence it is necessary to raise the temperature of the water in the colander to the temperature of the vapors to be condensed: therefore, I cause the lukewarm water, pumped from the reservoir F, to circulate in the chamber c. In this circulation it also begins to act as a refrigerating medium, taking up a portion of heat from the vapors that pass through the pipe D, and afterwards it acts as a further condenser in the cylinder, in the way described. Finally, the portion of this water that is still in the fluid state, after having fallen down from coil to coil, arrives lukewarm to the inclined surface L, which conducts it into the reservoir E, from whence it is pumped up into the chamber c, as before described.

"The tube or chimney κ may have more or less altitude; the higher it is the greater is the current produced. The force or velocity of the current of air can be governed by the areas of the introduction and exit apertures. If the cylinder rises only to the height of the sieve, the effect is much less than when it is prolonged beyond this height. I would further remark, that if the cylinder was removed, a slight effect might be produced, provided that a current of air be preserved in the cylindrical space limited by the coils of the worm, and also if the current was produced between the coils; or a central passage might be formed in an apparatus of another shape than that above described.

"I have only shown the application of the worm, because intending only to explain the principles of this method of condensing and refrigerating.

"The small quantity of water wasted in this manner of condensation, (that is, that portion passed off to the atmosphere in the form of vapors, at the upper aperture of the cylinder κ,) may be replaced by a small stream of cold water, which may be brought to the apparatus, and perhaps most conveniently introduced into the reservoir F, or into the chamber between the pipes B and c. When operating upon aqueous vapors, the waste of water is always less in weight than that of the vapors liquefied. When this apparatus is applied to the purposes of distillation, the end of the worm should terminate in a vessel M, which is to receive the produce of the condensation. It will be seen that this improved process is applicable to various purposes, where condensation or refrigeration is required; for instance, in the boiling or concentration of sugar; to condensing and refrigerating distilled vapors, or steam, or saline liquids, either in vacuum or not; to cooling brewers' worts; and to the refrigeration of other liquors, or any other processes, when it may be required."

I have inserted the specification of this patent *verbatim*. M. Derosne has busied

himself during a long life with a prodigious number of ingenious little contrivances for clarifying and boiling sirups, distillation, &c., but he has in this invention taken a bolder flight, having secured the exclusive privilege of condensing vapors, and cooling liquors, with hot water, in preference to cold. No man at all versant in the scientific doctrines, or the practical applications of caloric, will ever seek to meddle with his monopoly of such a scheme. He may find, perhaps, some needy coppersmith ready to espouse that or any other equally foolish project, provided a productive job can be made of it, against credulous customers.

For some rational methods of cooling liquors, and condensing vapors, see REFRIGERA-TION, STILL, and SUGAR.

COPAL, a resin which exudes spontaneously from two trees, the *Rhus copallinum*, and the *Elæocarpus copalifer*, the first of which grows in America, and the second in the East Indies. A third species of copal tree grows on the coasts of Guinea, especially on the banks of some rivers, among whose sands the resin is found. It occurs in lumps of various sizes and of various shades of color, from the palest greenish yellow to darkish brown. I found its specific gravity to vary in different specimens from 1·059 to 1·071, being intermediate in density between its two kindred resins, animé and amber. Some rate its specific gravity so high as 1·139, which I should think one of the errors with which chemical compilations teem. Copal is too hard to be scratched by the nail, whence the excellence of its varnish. It has a conchoidal fracture, and is without smell or taste. When exposed to heat in a glass retort over a spirit lamp, it readily melts into a liquid, which being further heated boils with explosive jets. A viscid oily-looking matter then distils over. After continuing the process for some time, no succinic acid is found in the receiver, but the copal blackens in the retort. Anhydrous alcohol boiled upon it, causes it to swell, and transforms it by degrees into an elastic viscid substance. It is not soluble in alcohol of 0·825 at the boiling point, as I have ascertained. Copal dissolves in ether, and this ethereous solution may be mixed with alcohol without decomposition. Caoutchoucine acts very slightly upon it by my experiments, even at the boiling temperature of this very volatile fluid; but a mixture of it with alcohol of 0·825 in equal parts dissolves it very rapidly in the cold into a perfectly liquid varnish. Alcohol holding camphor in solution also dissolves it, but not nearly so well as the last solvent. According to Unverdorben, copal may be completely dissolved by digesting one part of it for 24 hours with one part and a half of alcohol (probably anhydrous), because that portion of copal which is insoluble in alcohol dissolves in a very concentrated solution of the soluble portion. Oil of petroleum and turpentine dissolve only 1 or 2 per cent. of raw copal. By particular management, indeed, oil of turpentine may be combined with copal, as we shall describe under the article VARNISH.

Fused copal possesses different properties from the substance in its solid state; for it then may be made to combine both with alcohol and oil of turpentine.

Unverdorben has extracted from the copal of Africa five different kinds of resin, none of which has however been applied to any use in the arts.

The ultimate constituents of copal by my analysis are, carbon 79·87, hydrogen 9·00, oxygen 11·1; being of hydrogen 7·6 in excess above the quantity necessary to form water with the oxygen. Of copal and animé, 551,166 lbs. were imported in 1835.

COPPER is one of the metals most anciently known. It was named from the island of Cyprus, where it was extensively mined and smelted by the Greeks. It has a reddish brown color inclining to yellow; a faint but nauseous and rather disagreeable taste; and when rubbed between the fingers it imparts a smell somewhat analogous to its taste. Its specific gravity is from 8·8 to 8·9. It is much more malleable than it is ductile; so that far finer leaves may be obtained from it than wire. It melts at the 27th degree of Wedgewood's pyrometer, and at a higher temperature it evaporates in fumes which tinge the fire of a bluish green. By exposure to heat with access of air, it is rapidly converted into black scales of peroxyde. In tenacity it yields to iron; but surpasses gold, silver, and platinum, considerably in this respect.

In mineralogy, the genus copper includes about 13 different species, and each of these contains a great many varieties. These ores do not possess any one general exterior character by which they can be recognised; but they are readily distinguished by chemical re-agents. Water of ammonia digested upon any of the cupreous ores in a pulverized state, after they have been calcined either alone or with nitre, assumes an intense blue color, indicative of copper. The richest of the ordinary ores appear under two aspects; the first class has a metallic lustre, a copper red, brass yellow, iron gray, or blackish gray color, sometimes inclining to blue; the second is without metallic appearance, has a red color, verging upon purple, blue, or green, the last tint being the most usual. Few copper ores are to be met with, indeed, which do not betray the presence of this metal by more or less of a greenish film.

1. *Native copper* occurs in crystals, branches, and filaments, its most common locality being in primitive rocks. It is found abundantly in Siberia, at the mines of Tourinski, in those of Hungary, of Fundo-Moldavi in Gallicia, of Fahlun in Sweden,

of Cornwall, &c. The gangues of native copper are granite, gneiss, mica-slate, clay-slate, quartz, carbonate or fluate of lime, sulphate of barytes, &c. The most remarkable masses of native copper hitherto observed were—first, one in Brazil, 14 leagues from Basa, which weighed 2616 pounds; and secondly, another which Dr. Francis-le-Baron discovered in America to the south of Lake Superior. It was nearly 15 feet in circumference.

2. *Sulphuret of Copper, the vitreous ore of Brochant.* The texture of this ore is compact; its fracture, conchoidal, surface sometimes dull; color, iron black or lead gray, often bluish, iridiscent, or reddish from a mixture of protoxyde. It is easily melted even by the heat of a candle; but more difficult of reduction than protoxyde. This ore yields to the knife, assuming a metallic lustre when cut. Its density varies from 4·8 to 5·34. Its composition, according to Klaproth, is 78·5 copper, 18·5 sulphur, with a little iron and silica. Its equivalent constitution by theory is 80 copper + 20 sulphur = 100; whence 78·5 of metal should be associated with 19·6 of sulphur. This ore is therefore one of the richest ores, and forms very powerful veins, which likewise contain some orange protoxyde. It is to be found in all considerable copper districts; in Siberia, Saxony, Sweden, and especially Cornwall, where the finest crystals occur.

3. *Copper Pyrites* resembles in its metallic yellow hue, sulphuret of iron; but the latter is less pale, harder, and strikes fire more easily with steel. It presents the most lively rainbow colors. Its specific gravity is 4·3. It contains generally a good deal of iron, as the following analysis will show: copper 30, sulphur 37, iron 33, in 100 parts. According to Hisinger, the Swedish pyrites contains 63 of copper, 12 of iron, and 25 of sulphur. These ores occur in primitive and transition districts in vast masses and powerful veins; and are commonly accompanied with gray copper, sulphuret of iron, sparry iron, sulphurets of lead, and zinc.

4. *Gray Copper* has a steel gray color, more or less deep, either shining or dull; fracture uneven; a distinct metallic lustre; difficult of fusion at the blowpipe; it communicates to glass of borax a yellowish-red color. Its density in crystals is 4·86. Its composition is very variable; consisting essentially of copper, iron, antimony, and sulphur. The exploration of this ore is profitable, in consequence of the silver which it frequently contains. It occurs in primitive mountains; and is often accompanied with red silver ore, copper pyrites, and crystallized quartz.

5. *Protoxyde of Copper,* or *red oxyde of Copper :* its color is a deep red, sometimes very lively, especially when bruised. It is friable, difficult of fusion at the blowpipe, reducible on burning charcoal, soluble with effervescence in nitric acid, forming a green liquid. Its constitution, when pure, is 88·9 copper + 11·1 oxygen = 100.

6. *Black oxyde of Copper* is of a velvet black, inclining sometimes to brown or blue; and it acquires the metallic lustre on being rubbed. It is infusible at the blowpipe. Its composition is, copper 80 + oxygen 20; being a true peroxyde.

7. *Hydrosilicate of Copper* consists essentially of oxyde of copper, silica, and water. Its color is green; and its fracture is conchoidal with a resinous lustre, like most minerals which contain water. Its specific gravity is 2·73. It is infusible at the blowpipe alone, but it melts easily with borax.

8. *Dioptase Copper,* or *Emerald Malachite ;* a beautiful but rare cupreous mineral, consisting of oxyde of copper, carbonate of lime, silica, and water in varying proportions.

9. *Carbonate of Copper, Malachite,* is of a blue or green color. It occurs often in beautiful crystals.

10. *Sulphate of Copper, Blue Vitriol,* similar to the artificial salt of the laboratory. The blue water which flows from certain copper mines is a solution of this salt. The copper is easily procured in the metallic state by plunging pieces of iron into it.

11. *Phosphate of Copper* is of an emerald green, or verdigris color, with some spots of black. It presents fibrous or tuberculous masses with a silky lustre in the fracture. It dissolves in nitric acid without effervescence, forming a blue liquid; melts at the blowpipe, and is reducible upon charcoal, with the aid of a little grease, into a metallic globule. Its powder does not color flame green, like the powder of muriate of copper.

12. *Muriate of Copper* is green of various shades; its powder imparts to flame a remarkable blue and green color. It dissolves in nitric acid without effervescence; and is easily reduced before the blowpipe. Its density is 3·5. By Klaproth's analysis, it consists of oxyde of copper 73, muriatic acid 10, water 17.

13. *Arseniate of Copper.* It occurs in beautiful blue crystals. Before the blowpipe it melts, exhaling fumes of a garlic odor, and it affords metallic globules when in contact with charcoal. See more upon the ores at the end of this article.

In the article METALLURGY, I have described the mode of working certain copper mines; and shall content myself here with giving a brief account of two cupreous formations, interesting in a geological point of view; that of the copper slate of Mansfeldt, and of the copper veins of Cornwall.

The curious strata of bituminous schist in the first of these localities, are among the

most ancient of any which contain the exuviæ of organized bodies not testaceous. From among their tabular slabs the vast multitudes of fossil fish were extracted, which have rendered the cantons of Mansfeldt, Eisleben, Ilmenau, and other places in Thuringia and Voigtland so celebrated. Many of the fish are transformed into copper pyrites. Here, also, have been found the fossil remains of the lizard family, called *Monitors.*

Such is the influence of a wise administration upon the prosperity of mines, that the thin layer of slate in this formation, of which 100 pounds commonly contain but one pound and a half of copper, occasionally argentiferous, has been for several centuries the object of smelting works of the greatest importance to the territory of Mansfeldt and the adjoining country.

The frequent derangements which this metallic deposite experiences, led skilful directors of the under-ground operations at an early period to study the order of superposition of the accompanying rocks. From their observations, there resulted a system of facts which have served to guide miners, not only in the country of Mansfeldt, but over a great por tion of Germany, and in several other countries where the same series of rocks, forming the immediate envelope of the cupreous schists, were found to occur in the same order of superposition.

Of the English copper works.—The deposites of copper in Cornwall occur always as veins in granite, or in the schistose rocks which surround and cover it; and hence, the Cornish miners work mostly in the granite or greenish clay slate; the former of which they call *growan*, the latter *killas.* But tin is sometimes disseminated in small veins in porphyry or *elvan*, which itself forms great veins in the above rocks. No stratification has been observed in Cornwall.

The copper veins are abundant in the killas and rare in the granite; but most numerous near the line of junction of the two rocks. The different kinds of mineral veins in Cornwall may be classed as follows:—

1. Veins of elvan; elvan courses, or elvan channels.
2. Tin veins, or tin *lodes*; the latter word being used by the Cornish miners to signify a vein rich in ore, and the word *course*, to signify a barren vein.
3. Copper veins running east and west; east and west copper lodes.
4. Second system of copper veins, or *contra* copper lodes.
5. Crossing veins; cross courses.
6. Modern copper veins; more recent copper lodes.
7. Clay veins; of which there are two sets, the more ancient, called *Cross-Fluckans;* and the more modern, called *Slides.*

There are therefore three systems of copper veins in Cornwall; of which the first is considered to be the most ancient, because it is always traversed by the two others, and because, on the contrary, it never cuts them off. The width of these veins does not exceed 6 feet, though occasional enlargements to the extent of 12 feet sometimes take place. Their length is unknown, but the one explored in the *United Mines* has been traced over an extent of seven miles. The gangue of these veins is generally quartz, either pure, or mixed with green particles analogous to chlorite. They contain iron pyrites, blende, sulphuret, and several other compounds of copper, such as the carbonate, phosphate, arseniate, muriate, &c. The most part of the copper veins are accompanied with small argillaceous veins, called by the miners *fluckan of the lode.* These are often found upon both sides of the veins, so as to form cheeks or *salebandes.*

When two veins intersect each other, the direction of the one thrown out becomes an object of interest to the miner and geologist. In Saxony it is regarded as a general fact that the rejected portion is always to the side of the *obtuse angle;* this also holds generally in Cornwall, and the more obtuse the angle of incidence, the more considerable the out-throw.

The great copper vein of *Carharack*, in the parish of Gwenap, is a most instructive example of intersection. The power of this vein is 8 feet; it runs nearly from east to west, and dips toward the north at an inclination of 2 feet in a fathom. Its upper part is in the killas, its lower part in the granite. The vein has suffered two intersections; the first results from encountering the vein called *Steven's fluckan*, which runs from north-east to south-west, throwing it out several fathoms. The second has been caused by another vein, almost at right angles to the first, and which has driven it 20 fathoms out to the right side. The fall of the vein occurs, therefore, in one case to the right, and in the other to the left; but in both instances, it is to the side of the obtuse angle. This disposition is very singular; for one portion of the vein appears to have ascended, while another has sunk.

The mining works in the copper veins are carried on by reverse steps; see MINES The grand shafts for drainage and extraction are vertical, and open upon the roof side of the vein, traversing it to a certain depth. These pits are sunk to the lowest point of the exploration; and, in proportion as the workings descend, by means of excavations in the vein, the pits are deepened and put into communication toward their bottom with

each new gallery of elongation, by means of transverse galleries. At present, the main shafts are fully 160 fathoms deep. Their horizontal section is oblong, and is divided into two compartments; the one destined for extraction, the other for the pumps. Their timbering has nothing remarkable, but is executed with every attention to economy, the whole wood employed in these mines being brought from Norway.

The descent of the workmen is effected by inclined shafts scooped out of the vein; the ladders are slightly inclined; they are interrupted every 10 fathoms by floors; the steps are made of iron, and, to prevent them from turning under the foot, the form of a miner's punch or jumper has been given them, the one end being round, and the other being wedge-shaped.

The ore is raised either by means of horse-gins, or by steam-engine power, most frequently of high pressure. I shall take the *Consolidated Mines* as an example.

The draining, which is one of the most considerable sources of expense, both from the quantity of water, and from the depth of the mine, is executed by means of sucking and forcing pumps, the whole piston-rods of which, 120 feet long, are attached to a main-rod suspended at the extremity of the working beam of a steam-engine.

On this mine three steam-engines are erected of very great power, for the purpose of drainage; the one called the *Maria* engine is of the first-rate force, and most improved construction. The cylinder is 90 inches in internal diameter, and the length of the stroke is 9 feet 11 inches. It works single stroke, and is incased in a coating of bricks to prevent dissipation of the heat. The vapor is admitted at the upper end of the cylinder during the commencement of the fall of the piston, at a pressure capable of forming an equilibrium with a column of 60 inches of mercury. The introduction of the steam ceases whenever the piston has descended through a certain space, which may be increased or diminished at pleasure. During the remainder of the descent the piston is pressed merely by this vapor in its progressive expansion, while the under side of the piston communicates with the condenser. It ascends by the counterweight at the pump end of the working beam. Hence, it is only during the descent of the piston that the effective stroke is exerted. Frequently the steam is admitted only during the sixth part of the course of the piston, or 18 inches. In this way the power of the engine is proportioned to the work to be done; that is, to the body of water to be raised. The *maximum* force of the above engine is about 310 horses; though it is often made to act with only one third of this power.

The copper mines of the Isle of Anglesey, those of North Wales, of Westmoreland, the adjacent parts of Lancashire and Cumberland, of the south west of Scotland, of the Isle of Man, and of the south east of Ireland, occur also in primitive or transition rocks. The ores lie sometimes in masses, but more frequently in veins. The mine of Ecton in Staffordshire, and that of Cross-gill burn, near Alston-moor in Cumberland, occur in transition or metalliferous limestone.

The copper ores extracted both from the granitic and schistose localities, as well as from the calcareous, are uniformly copper pyrites more or less mixed with iron pyrites; the red oxyde, carbonate, arseniate, phosphate, and muriate of copper, are very rare in these districts.

The working of copper in the Isle of Anglesey may be traced to a very remote era. It appears that the Romans were acquainted with the Hamlet mine near Holyhead; but it was worked with little activity till about 70 years ago. This metalliferous deposite lies in a greenish clay slate, passing into talc slate; a rock associated with serpentine and euphotide (*gabbro* of Von Buch). The veins of copper are from one to two yards thick, and they converge towards a point where their union forms a considerable mass of ore. On this mass the mine was first pierced by an open excavation, which is now upwards of 300 feet deep, and appears from above like a vast funnel. Galleries are formed at different levels upon the flank of the excavation to follow the several small veins, which run in all directions, and diverge from a common centre like so many radii. The ore receives in these galleries a kind of sorting, and is raised by means of hand windlasses to the summit of a hill, where it is cleaned by breaking and riddling.

The water is so scanty in this mine that it is pumped up by a six-horse steam-engine. A great proportion of it is charged with sulphate of copper. It is conveyed into reservoirs containing pieces of old iron; the sulphate is thus decomposed into copper of cementation. The Anglesea ore is poor, yielding only from 2 to 3 *per cent.* of copper: a portion of its sulphur is collected in roasting the ore.

Mechanical preparation of the copper ores in Cornwall.—The ore receives a first sorting, either within the mine itself, or at its mouth, the object of which is to separate all the pieces larger than a walnut. These are then reduced by the hammer to a smaller size; after which the whole are sorted into four lots, according to their relative richness. The fragments of poor ore are pounded in the stamps so that the metallic portion may be separated by washing.

The rich ore is broken into small bits, of the size of a nut, with a flat beater, formed

of a piece of iron 6 inches square and 1 inch thick, adapted to a wooden handle. The ore to be broken is placed upon plates of cast-iron; each about 16 inches square and 1½ inch thick. These iron plates are set towards the edge of a small mound about a yard high, constructed with dry stones rammed with earth. The upper surface of this mound is a little inclined from behind forwards. The work is performed by women, each furnished with a beater; the ore is placed in front of them beyond the plates; they break it, and strew it at their feet, whence it is lifted and disposed of to the smelting-houses.

Inferior ores, containing a notable proportion of stony matters, are also broken with the beater, and the rich parts are separated by riddling and washing from the useless matters.

The smaller ore is washed on a sieve by shaking it in a stream of water, which carries away the lighter stony pieces, and leaves the denser metalliferous. They are then sorted by hand. Thus by beating, stamping, and riddling in water, the stony substances are in a great measure separated. The finer ground matter is washed on a plane table, over which a current of water is made to flow. Finally, the ore nearly fine is put into a large tub with water, and briskly stirred about with a shovel, after which it settles in the order of richness, the pure metallic ore being nearest the bottom. The stamps used for copper ore in Cornwall are the same as those used for tin ores, of which we shall speak in treating of the latter metal, as well as of the boxes for washing the fine powder or *slime*. These, in fact, do not differ essentially from the stamping mills and washing apparatus described in the article METALLURGY. Crushing rolls are of late years much employed. See LEAD and TIN.

Cornwall being destitute of coal, the whole copper ore which this county produces is sent for smelting to South Wales. Here are 15 copper works upon the Swansea and Neath, which pursue a nearly uniform and much improved process, consisting in a series of calcinations, fusions, and roastings, executed upon the ores and the matters resulting from them.

The furnaces are of the reverberatory construction; they vary in their dimensions and in the number of their openings, according to the operations for which they were intended. There are 5 of them :—1. The calcining furnace or calciner; 2. The melting furnace; 3. The roasting furnace or roaster; 4. The refining furnace; 5. The heating or igniting furnace.

1. The calcining furnace rests upon a vault, c, into which the ore is raked down after being calcined; it is built of bricks, and bound with iron bars, as shown in the elevation, *fig.* 296. The hearth, B B, *figs.* 296 and 298, is placed upon a level with the lower horizontal binding bar, and has nearly the form of an ellipse, truncated at the two extremities of its great axis. It is horizontal, bedded with fire-bricks set on edge, so that it may be removed and repaired without disturbing the arch upon which it reposes. Holes, not visible
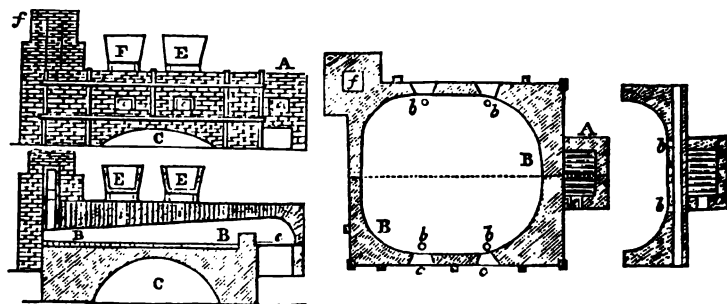
in the figure, are left in the shelves before each door, c c, through which the roasted ore is let fall into the subjacent vault. The dimensions of the hearth B B are immense, being from 17 to 19 feet in length, and from 14 to 16 in breadth. The fire-place, A, *fig.* 298, is from 4½ to 5 feet long, and 3 feet wide. The bridge or low wall, b, *fig.* 302, which separates the fire-place from the hearth, is 2 feet thick; and in Mr. Vivian's smelting-works is hollow, as shown in the figure, and communicates at its two ends with the atmosphere, in order to conduct a supply of fresh air to the hearth of the furnace. This judicious contrivance will be described in explaining the *roasting* operation. The arched roof of the furnace slopes down from the bridge to the beginning of the chimney, f, *figs.* 297, 298, its height above the hearth being at the first point about 26 inches, and from 8 to 12 at the second.

Such great calcining furnaces have 4 or 5 doors, c c c c, *fig.* 298, one for the fire-place, as shown at the right hand in *fig.* 297, and 3 or 4 others for working the ore upon the

ratory hearth. If there be 3, 2 of them are placed between the vertical binding
pon one side, and a third upon the opposite side of the furnace; if there be 4, 2
ced upon each side, facing one another. These openings are 12 inches square,
e bound with iron frames. The chimney is about 22 feet high, and is placed at
gle of the hearth, as at *f, fig.* 298, being joined by an inclined flue to the furnace.
charging it with ore there are usually placed above the upper part of the vault 2
s, E E, in a line with the doors; they are formed of 4 plates of iron, supported in
frame. Beneath each of them there is an orifice for letting the ore down into the

e furnaces serve for calcining the ore, and the *matts* or *crude coppers* : for the latter
e, indeed, furnaces of two stories are sometimes employed, as represented in *fig.* 301.
mensions of each floor in this case are a little less than the preceding. Two doors,
respond to each hearth, and the workmen, while employed at the upper story, stand
raised moveable platform.
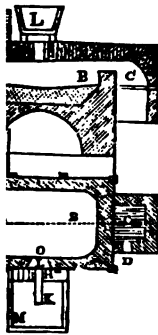
2. *Melting furnace, figs.* 299 and 300. The form of the
hearth is also elliptical, but the dimensions are smaller than
in the calcining furnace. The length does not exceed 11 or 11½
feet, and the breadth varies from 7 to 8. The fire-place is
however larger in proportion, its length being from 3½ feet
to 4, and its breadth from 3 to 3½; this size being requisite
to produce the higher temperature of this furnace. It has
fewer openings, there being commonly three; one to the
fire-place at D, a second one, o, in the side, kept generally
shut, and used only when incrustations need to be scraped
off the hearth, or when the furnace is to be entered for
repairs; and the third or working-door, G, placed on the
front of the furnace beneath the chimney. Through it the
scoriæ are raked out, and the melted matters are stirred and
puddled, &c.

The hearth is bedded with infusible sand, and slopes
slightly towards the side door, to facilitate the discharge of
the metal. Above this door there is a hole in the wall of the
F (*fig.* 300) for letting the metal escape. An iron gutter, o, leads it into a pit, x,
d with an iron receiving-pot, which may be lifted out by a crane. The pit M is
ith water, and the metal becomes granulated as it falls into the receiver. The
furnaces are surmounted by a hopper, L, as shown in *fig.* 299.
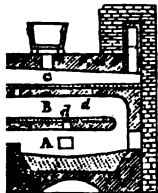
Melting furnaces are sometimes used also for calcination.
There are some such near Swansea, which serve this double
purpose; they are composed of 3 floors (*fig.* 301.) The floor
A is destined for melting the calcined ore; the other two,
B C, serve for calcination. The heat being less powerful,
upon the upper sole C, the ore gets dried upon it, and begins
to be calcined — a process completed on the next floor.
Square holes, d, left in the hearths B and C, put them in
communication with each other, and with the lower one A;
these perforations are shut during the operation by a sheet
removeable at pleasure.

hearths *b* and *c* are made of bricks; they are horizontal at top and slightly vaulted
; they are 2 bricks thick, and their dimensions are larger than those of the info-
rths, as they extend above the fire-place. On the floors destined for calcination
ace has two doors on one of its sides : on the lower story there are also two; but
: differently collocated. The first, being in the front of the furnace, serves for
off the scoriæ, for working the metal, &c.; and the second, upon the side, admits
n to make necessary repairs. Below this door the discharge or tap-hole A is
which communicates by a cast-iron gutter with a pit filled with water. The
ons of this furnace in length and breadth are nearly the same as those of the
furnace above described; the total height is nearly 12 feet. It is charged by
f one or two hoppers.

asting furnace. — The furnaces employed for this purpose are in general analo-
the calcining ones; but in the smelting works of Hafod, the property of Messrs.
these furnaces, alluded to above, present a peculiar construction, for the purpose
ducing a continuous current of air upon the metal, in order to facilitate its oxy-
t. This process was originally invented by Mr. Sheffield, who disposed of his
ight to Messrs. Vivian.

ir is admitted by a channel, *c c,* through the middle of the fire-bridge, *fig.* 302, and
g all its length; it communicates with the atmosphere at its two ends *c c;*
holes, *b b,* left at right angles to this channel, conduct the air into the fur-

nace. This very simple construction produces a powerful effect in the roasting opera-
tion. It not only promotes the oxydizement of the metals, but burns the smoke, and as-
sists in the vaporization of the sulphur ; while by keeping the bridge cool it preserves it
from wasting, and secures uniformity of temperature to the hearth.

4. *Refining furnace.* — In this, as in the melting furnace, the sole slopes towards
the door in front, instead of towards the side doors, because in the refining furnace the
copper collects into a cavity formed in the hearth towards the front door, from which it
is lifted out by ladles ; whereas, in the melting furnaces, the metal is run out by a tap-
hole in the side. The hearth sole is laid with sand; but the roof is higher than in the
melting furnace, being from 32 to 36 inches. If the top arch were too much depressed,
there might be produced upon the surface of the metal a layer of oxyde very prejudicial
to the quality of the copper. When the metal in that case is run out, its surface so-
lidifies and cracks, while the melted copper beneath breaks through and spreads irregu-
larly over the cake. This accident, called the *rising of the copper*, hinders it from being
laminated, and requires it to be exposed to a fresh refining process, when lead must be
added to dissolve the oxyde of copper. This is the only occasion upon which the addi-
tion of lead is proper in refining copper. When the metal to be refined is mixed with
others, particularly with tin, as in extracting copper from old bells, then very wide fur-
naces must be employed, to expose the metallic bath upon a great surface, and in a thin
stratum, to the oxydizing action of the air.

The door G, *fig.* 300, upon the side of the refining furnace, is very large, and is shut
with a framed brick door, balanced by a counter-weight. This door being open during
the refining process, the heat is stronger at B than at A, (*figs.* 299, 300.)

5. *Heating furnaces*, being destined to heat the pigs or bars of copper to be laminated,
as well as the copper sheets themselves, are made much longer in proportion to their
breadth. Their hearth is horizontal, the vault not much depressed; they have only one
door, placed upon the side, but which extends nearly the whole length of the furnace;
this door may be raised by means of a counter-weight, in the same way as in the furnaces
for the fabrication of sheet-iron and brass.

Series of operations to which the ore is subjected. — The ores which are smelted in the
Swansea works are cupreous pyrites, more or less mingled with *gangue* (vein-stone). The
pyrites is composed of nearly equal proportions of sulphuret of copper and sulphuret of
iron.

The earthy matters which accompany the pyrites are usually silicious, though in some
mines the metalliferous deposite is mixed with clay or fluate of lime. Along with these
substances, pretty uniformly distributed, tin and arsenical pyrites occur occasionally
with the copper; and though these two metals are not chemically combined, yet they
cannot be separated entirely in the mechanical preparations. The constituent parts of
the ore prepared for smelting are, therefore, copper, iron, sulphur, with tin, arsenic,
and earthy matters in some cases. The different ores are mixed in such proportions
that the average metallic contents may amount to $8\frac{1}{2}$ per cent. The smelting process
consists in alternate roastings and fusions. The following description of it is chiefly
taken from an excellent paper, published by John Vivian, Esq., in the Annals of Philo-
sophy for 1823.

In the roasting operation the volatile substances are disengaged mostly in the gaseous
state, while the metals that possess a strong affinity for oxygen become oxydized. In
the fusion the earthy substances combine with these oxydes, and form glassy scoriæ or
slags which float upon the surface of the melted metal.

These calcinations and fusions take place in the following order : —

1. Calcination of the ore. 2. Melting of the calcined ore. 3. Calcination of the
coarse metal. 4. Melting of the calcined coarse metal. 5. Calcination of the fine
metal (second matt). 6. Melting of the calcined fine metal. 7. Roasting of the
coarse copper. In some smelting works, this roasting is repeated four times; in
which case a calcination and a melting are omitted. In the Havod works, however,
the same saving is made without increasing the number of roastings. 8. Refining or
toughening the copper.

Besides these operations, which constitute the treatment of copper properly speaking,
two others are sometimes performed, in which only the scoriæ are melted. These ma
be designated by the letters *a* and *b*. *a* is the re-melting of the portion of the scoriæ
of the second process, which contain some metallic granulations. *b* is a particular melt-
ing of the scoriæ of the fourth operation. This fusion is intended to concentrate th
particles of copper in the scoriæ, and is not practised in all smelting works.

First operation. Calcination of the ore. — The different ores, on arriving from Corn
wall and other districts where they are mined, are discharged in continuous cargoes
the smelting works, in such a way, that by taking out a portion from several heaps
a time, a tolerably uniform mixture of ores is obtained; which is very essential i
a foundry, because, the ores being different in qualities and contents, they act

fluxes upon each other. The ore thus mixed is transported to the works in wooden measures that hold a hundred-weight. The workmen intrusted with the calcination convey the ore into the hoppers of the calcining furnace, whence it falls into the hearth; other workmen spread it uniformly on the surface by iron rakes. The charge of a furnace is from three tons to three tons and a half. Fire is applied and gradually increased, till, towards the end of the operation, the temperature be as high as the ore can support without melting or agglutinating. To prevent this running together, and to aid the extrication of the sulphur, the surfaces are renewed, by stirring up the ore at the end of every hour. The calcination is usually completed at the end of 12 hours, when the ore is tumbled into the arch under the sole of the furnace. Whenever the ore is cold enough to be moved, it is taken out of the arch, and conveyed to the calcined heap.

The ore in this process hardly changes weight, having gained in oxydizement nearly as much as it has lost in sulphur and arsenic; and if the roasting has been rightly managed, the ore is in a black powder, owing to the oxyde of iron present.

Second operation. Fusion of the calcined ore.—The calcined ore is likewise given to the melters in measures containing a hundred weight. They toss it into hoppers, and after it has fallen on the hearth, they spread it uniformly. They then let down the door, and lute it tightly. In this fusion there are added about 2 cwt. of scoriæ proceeding from the melting of the calcined matt, to be afterwards described. The object of this addition is not only to extract the copper that these scoriæ may contain, but especially to increase the fusibility of the mixture. Sometimes also, when the composition of the ore requires it, lime, sand, or fluor spar is added; and particularly the last fluxing article.

The furnace being charged, fire is applied, and the sole care of the founder is to keep up the heat so as to have a perfect fusion; the workman then opens the door, and stirs about the liquid mass to complete the separation of the metal (or rather of the matt) from the scoriæ, as well as to hinder the melted matter from sticking to the sole. The furnace being ready, that is, the fusion being perfect, the founder takes out the scoriæ by the front door, by means of a rake. When the matt is thus freed from the scoriæ, a second charge of calcined ore is then introduced to increase the metallic bath; which second fusion is executed like the first. In this way, new charges of roasted ore are put in till the matt collected on the hearth rises to a level with the door-way, which happens commonly after the third charge. The tap hole is now opened; the matt flows out into the pit filled with water, where it is granulated during its immersion; and it collects in the pan placed at the bottom. The granulated matt is next conveyed into the matt warehouse. The oxydation with which the grains get covered by the action of the water does not allow the proper color of the matt or coarse metal to be distinguished; but in the bits which stick in the gutter, it is seen to be of a steel gray. Its fracture is compact, and its lustre metallic. The scoriæ often contain metallic grains; they are broken and picked with care. All the portions which include some metallic particles are re-melted in an accessory process. The rejected scoriæ have been found to be composed of silicious matter 59, oxyde of copper 1, oxyde of tin 0·7.

In this operation, the copper is concentrated by the separation of a great part of the matters with which it was mixed or combined. The granulated matt produced, contains in general 33 per cent. of copper; it is therefore four times richer than the ore; and its mass is consequently diminished in that proportion. The constituent parts are principally copper, iron, and sulphur.

The most important point to hit in the fusion just described, is to make a fusible mixture of the earths and the oxydes, so that the matt of copper may, in virtue of its greater specific gravity, fall to the under-part, and separate exactly from the slag. This point is attained by means of the metallic oxydes contained in the scoriæ of the fourth operation, of which 2 cwt. were added to the charge. These consist almost entirely of black oxyde of iron. When the ores are very difficult to melt, a measure of about half a hundred-weight of fluor spar is added; but this must be done with precaution, for fear of increasing the scoriæ too much.

The business goes on day and night. Five charges are commonly put through hands in the course of 24 hours; but when all circumstances are favorable—that is to say, when the ore is fusible, when the fuel is of the first quality, and when the furnace is in good condition, even six charges a day have been despatched.

The charge is a ton and a half of calcined ore, so that a melting furnace corresponds nearly to a calcining furnace; the latter turning out nearly 7 tons of calcined ore in 24 hours.

The workmen are paid by the ton.

Third operation. Calcination of the coarse metal, or the matt.—The object of this operation is principally to oxydize the iron, an oxydation easier to execute than in the first

calcining, because the metal is now disengaged from the earthy substances, which screened it from the action of the air.

This calcination is executed in the furnace already represented, *figs.* 296, 297, 298, page 324, exactly in the same way as the ore was calcined. The metal must be perpetually stirred about, to expose all its surfaces to the action of the hot air, and to hinder the clotting together. The operation lasts 24 hours; during the first six, the fire should be very moderate, and thereafter gradually increased to the end of the calcination. The charge is, like that of the first, 3 tons and a half.

Fourth operation. Melting of the calcined coarse metal, or calcined matt.—In the fusion of this first calcined matt, some scoriæ of the latter operations must be added, which are very rich in oxyde of copper, and some crusts from the hearth, which are likewise impregnated with it. The proportion of these substances varies according to the quality of the calcined matt.

In this second fusion, the oxyde of copper contained in the scoriæ is reduced by the affinity of the sulphur, one portion of which passes to the state of acid, while the other forms a subsulphuret with the copper become free. The matt commonly contains a sufficient quantity of sulphur to reduce the oxyde of copper completely; but if not, which may happen if the calcination of the matt has been pushed too far, a small quantity of uncalcined matt must be introduced, which, by furnishing sulphur, diminishes the richness of the scoriæ, and facilitates the fusion.

The scoriæ are taken out by the front door, by drawing them forward with a rake. They have a great specific gravity; are brilliant with metallic lustre, very crystalline, and present, in the cavities, crystals like those of pyroxene; they break easily into very sharp-edged fragments. They contain no granulated metal in the interior; but it some times occurs, on account of the small thicknesses of the stratum of scoriæ, that these carry off with them, when they are withdrawn, some metallic particles.

These scoriæ, as we have already stated, under the fusion of the roasted ore, are in general melted with it. In some cases, however, a special melting is assigned to them.

The matt obtained in this second fusion is either run out into water like the first, or moulded into pigs (ingots), according to the mode of treatment which it is to undergo. This matt, called by the smelters *fine metal* when it is granulated, and *blue metal* when it is in pigs, is of a light gray color, compact, and bluish at the surface. It is collected in the first form when it is to be calcined anew; and in the second, when it must immediately undergo the operation of *roasting.* Its contents in copper are 60 *per cent.* This operation, which is sometimes had recourse to, lasts 5 or 6 hours. The charge is 1 ton.

(*b*) *Particular fusion of the scoriæ of the fourth operation.*—In re-melting these scoriæ, the object is to procure the copper which they contain. To effect this fusion, the scoriæ are mixed with pulverized coal, or other carbonaceous matters. The copper and several other metals are deoxydized, and furnish a white and brittle alloy. The scoriæ resulting from this melting are in part employed in the first melting, and in part thrown away. They are crystalline, and present crystals often in the cavities, which appear to belong to bisilicate of iron. They have a metallic lustre, and break into very sharp-edged fragments. The white metal is melted again, and then united to the product of the second fusion.

Fifth operation. Calcination of the second matt, or fine metal of the smelter.—This is executed in precisely the same way as that of the first matt. It lasts 24 hours; and the charge is usually 3 tons.

Sixth operation. Melting of the calcined fine metal.—This fusion is conducted like that of the first matt. The black copper, or coarse copper, which it produces, contains from 70 to 80 per cent. of pure metal; it is run into ingots, in order to undergo the operation of roasting.

The scoriæ are rich in copper; they are added to the fusion of the calcined coarse metal of the fourth operation.

In the smelting houses of Messrs. Vivian, at Hafod, near Swansea, the fifth and sixth operations have been omitted of late years. The second matt is run into pigs, under the name of *blue metal*, to be immediately exposed to the roasting.

The disposition of the canal *a a'*, *fig.* 302, which introduces a continuous current of air to the hearth of the furnace, accelerates and facilitates the calcination of the matt; an advantage which has simplified the treatment, by diminishing the number of calculations.

Seventh operation. Roasting of the coarse copper, the product of the sixth operation.— The chief object of this operation is oxydizement; it is performed either in an ordinary roasting furnace, or in the one belonging to *fig.* 302, which admits a constant current of air. The pigs of metal derived from the preceding melting are exposed, on the hearth of the furnace, to the action of the air, which oxydizes the iron and other foreign metals with which the copper is still contaminated. The duration of the roasting varies from

12 to 24 hours, according to the degree of purity of the crude copper. The temperature should be graduated, in order that the oxydizement may have time to complete, and that the volatile substances which the copper still retains may escape in the gaseous form. The fusion must take place only towards the end of the operation.

The charge varies from a ton and a quarter to a ton and a half. The metal obtained is run out into moulds of sand. It is covered with black blisters, like steel of cementation; whence it has got the name of blistered copper. In the interior of these pigs, the copper presents a porous texture, occasioned by the ebullition produced by the escape of the gases during the moulding. The copper being now almost entirely purged from the sulphur, iron, and the other substances with which it was combined, is in a fit state to be refined. This operation affords some scoriæ; they are very heavy, and contain a great deal of oxyde of copper, sometimes even metallic copper.

These scoriæ, as well as those of the third melting and of the refining, are added to the second fusion, as we have already stated, in describing the fourth operation.

In some works, the roasting is repeated several times upon the *blue metal*, in order to bring it to a state fit for refining. We shall afterwards notice this modification of the treatment.

Eighth operation. Refining or toughening. — The pigs of copper intended for refining are put upon the sole of the refining furnace through the door in the side. A slight heat is first given, to finish the roasting or oxydation, in case this operation has not already been pushed far enough. The fire is to be increased by slow degrees, so that, by the end of 6 hours, the copper may begin to flow. When all the metal is melted, and when the heat is considerable, the workman lifts up the door in the front, and withdraws with a rake the few scoriæ which may cover the copper bath. They are red, lamellated, very heavy, and closely resemble protoxyde of copper.

The refiner takes then an assay with a small ladle, and when it cools, breaks it in a vice, to see the state of the copper. From the appearance of the assay, the aspect of the bath, the state of the fire, &c., he judges if he may proceed to the toughening, and what quantity of wooden spars and wood charcoal he must add to render the metal malleable, or, in the language of the smelters, bring it to the proper pitch. When the operation of refining begins, the copper is brittle or dry, and of a deep red color approaching to purple. Its grain is coarse, open, and somewhat crystalline.

To execute the refining, the surface of the metal is covered over with wood charcoal, and stirred about with a spar or rod of birch wood. The gases which escape from the wood occasion a brisk effervescence. More wood charcoal is added from time to time, so that the surface of the metal may be always covered with it, and the stirring is continued with the rods, till the operation of refining be finished, a circumstance indicated by the assays taken in succession. The grain of the copper becomes finer and finer, and its color gradually brightens. When the grain is extremely fine, or *closed*, when the trial pieces, half cut through and then broken, present a silky fracture, and when the copper is of a fine light red, the refiner considers the operation to be completed; but he verifies still further the purity of the copper, by trying its malleability. For this purpose, he takes out a sample in his small ladle, and pours it into a mould. When the copper is solidified, but still red-hot, he forges it. If it is soft under the hammer, if it does not crack on the edges, the refiner is satisfied with its ductility, and he pronounces it to be in its *proper state.* He orders the workmen to mould it; who then lift the copper out of the furnace in large iron ladles lined with clay, and pour it into moulds of the size suitable to the demands of commerce. The ordinary dimensions of the ingots or pigs are 12 inches broad, 18 long, and from 2 to 2½ thick.

The period of the refining process is 20 hours. In the first six, the metal heats, and suffers a kind of roasting; at the end of this time it melts. It takes four hours to reach the point at which the refining, properly speaking, begins; and this last part of the process lasts about 4 hours. Finally, 6 hours are required to arrange the moulds, cast the ingots, and let the furnace cool.

The charge of copper in the refining process depends upon the dimensions of the furnace. In the Hafod works, one of the most important in England, the charge varies from 3 to 5 tons; and the quantity of pure copper manufactured in a week is from 40 to 50 tons. The consumption of fuel is from 15 to 18 parts of coal, for one part of refined copper in pigs.

When the copper offers difficulties in the refining, a few pounds of lead are added to it. This metal, by the facility with which it scorifies, acts as a purifier, aiding the oxydation of the iron and other metals that may be present in the copper. The lead ought to be added immediately after removing the door to skim the surface. The copper should be constantly stirred up, to expose the greatest possible surface to the action of the air, and to produce the complete oxydation of the lead; for the smallest quantity of this metal alloyed in copper, is difficult to clear up in the lamination; that is to say, the scale of oxyde does not come cleanly from the surface of the sheets.

The operation of refining copper is delicate, and requires, upon the part of the workmen, great skill and attention to give the metal its due ductility. Its surface ought to be entirely covered with wood charcoal; without this precaution, the refining of the metal would *go back*, as the workmen say, during the long interval which elapses in the moulding; whenever this accident happens, the metal must be stirred up anew with the wooden pole.

Too long employment of the wooden rod gives birth to another remarkable accident, for the copper becomes more brittle than it was prior to the commencement of the refining; that is, when it was *dry*. Its color is now of a very brilliant yellowish red, and its fracture is fibrous. When this circumstance occurs, when the refining, as the workmen say, has *gone too far*, the refiner removes the charcoal from the top of the melted metal; he opens the side door, to expose the copper to the action of the air, and it then resumes its malleable condition.

Mr. Vivian, to whom we owe the above very graphic account of the processes, has explained, in a very happy manner, the theory of refining. He conceives, we may conclude, that the copper in the *dry state*, before the refining, is combined with a small portion of oxygen, or, in other words, that a small portion of oxyde of copper is diffused through the mass, or combined with it; and that this proportion of oxygen is expelled by the deoxydizing action of the wood and charcoal, whereby the metal becomes malleable. 2. That when the refining process is carried too far, the copper gets combined with a little charcoal. Thus copper, like iron, is brittle when combined with oxygen and charcoal; and becomes malleable only when freed entirely from these two substances.

It is remarkable, that copper, in the *dry state*, has a very strong action upon iron; and that the tools employed in stirring the liquid metal become very glistening, like those used in a farrier's forge. The iron of the tools consumes more rapidly at that time, than when the copper has acquired its malleable state. The metal requires, also, when dry, more time to become solid, or to cool, than when it is refined; a circumstance depending, probably, upon the difference in fusibility of the copper in the two states, and which seems to indicate, as in the case of iron, the presence of oxygen.

When the proper refining point has been passed, another very remarkable circumstance has been observed; namely, that the surface of the copper oxydizes more difficultly, and that it is uncommonly brilliant; reflecting clearly the bricks of the furnace vault. This fact is favorable to the idea suggested above, that the metal is in that case combined with a small quantity of carbon; which absorbs the oxygen of the air, and thus protects the metal from its action.

Copper is brought into the market in different forms, according to the purposes which it is to serve. What is to be employed in the manufacture of brass is granulated. In this condition it presents more surface to the action of zinc or calamine, and combines with it more readily. To produce this granulation, the metal is poured into a large ladle pierced with holes, and placed above a cistern filled with water, which must be hot or cold, according to the form wished in the grains. When it is hot, round grains are obtained analogous to lead shot; and the copper in this state is called *bean shot*. When the melted copper falls into cold water perpetually renewed, the granulations are irregular, thin, and ramified; constituting *feathered shot*. The *bean shot* is the form employed in brass making.

Copper is also made into small ingots, about 6 ounces in weight. These are intended for exportation to the East Indies, and are known in commerce by the name of Japan copper. Whenever these little pieces are solidified, they are thrown, while hot, into cold water. This immersion slightly oxydizes the surface of the copper, and gives it a fine red color.

Lastly, the copper is often reduced into sheets, for the sheathing of ships, and many other purposes. The Hafod works possess a powerful rolling mill, composed of four pairs of cylinders. It is moved by a steam engine, whose cylinder has 40 inches diameter. See the representation of the rolling mill of the Royal Mint, under GOLD.

The cylinders for rolling copper into sheets are usually 3 feet long, and 15 inches in diameter. They are uniform. The upper roller may be approached to the under one, by a screw, so that the cylinders are brought closer, as the sheet is to be made thinner.

The ingots of copper are laid upon the sole of a reverberatory furnace to be heated; they are placed alongside each other, and they are formed into piles in a cross-like arrangement, so that the hot air may pass freely round them all. The door of the furnace is shut, and the workman looks in through a peep-hole from time to time, to see if they have taken the requisite temperature; namely, a dull red. The copper is now passed between the cylinders; but although this metal be very malleable, the ingots cannot be reduced to sheets without being several times heated; because the copper cools, and ac requires, by compression, a texture which stops the progress of the lamination.

These successive heatings are given in the furnace indicated above; though, when the

sheets are to have a very great size, furnaces somewhat different are had recourse to. They are from 12 to 15 feet long, and 5 wide. See Brass.

The copper, by successive heating and lamination, gets covered with a coat of oxyde, which is removed by steeping the sheets for a few days in a pit filled with urine; they are then put upon the sole of the heating furnace. Ammonia is formed, which acts on the copper oxyde, and lays bare the metallic surface. The sheets are next rubbed with a piece of wood, then plunged, while still hot, into water, to make the oxyde scale off; and lastly, they are passed cold through the rolling press to smooth them. They are now cut square, and packed up for home sale or exportation.

The following estimate has been given by MM. Dufrenoy and Elie de Beaumont of the expense of manufacturing a ton of copper in South Wales.

	£	s.	d.
12½ tons of ore, yielding 8½ per cent. of copper	55	0	0
20 tons of coals	8	0	0
Workmen's wages, rent, repairs, &c.	13	0	0
	76	0	0

The exhalations from the copper smelting works are very detrimental to both vegetable and animal life. They consist of sulphurous acid, sulphuric acid, arsenic, and arsenious acids, various gases and fluoric vapors, with solid particles mechanically swept away into the air, besides the coal smoke. Mr. Vivian has invented a very ingenious method of passing the exhalations from the calcining ores and matts along horizontal flues, or rather galleries of great dimensions, with many crossings and windings of the current, and exposure during the greater part of the circuit to copious showers of cold water. By this simple and powerful system of condensation, the arsenic is deposited in the bottoms of the flues, the sulphurous acid is in a great measure absorbed, and the nuisance is remarkably abated.

The following figures represent certain modifications of the copper calcining and smelting copper furnaces of Swansea.

Fig. 304, is the section of the roasting furnace lengthwise; fig. 303, the ground plan; in which a is the fire-door; b the grate; c the fore-bridge; d the chimney; e e working
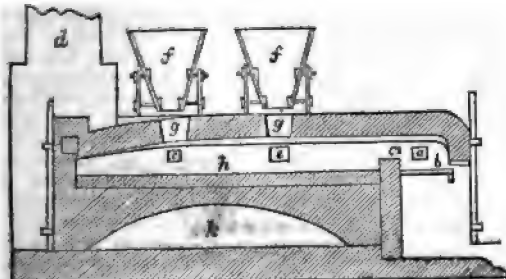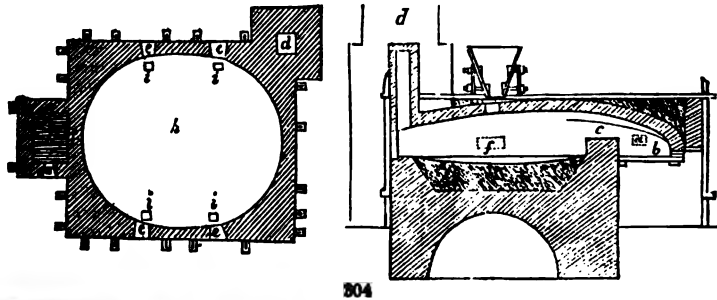
apertures on each of the long sides of the furnace, through which the ore is introduced, spread, and turned over; ff cast-iron hoppers; g g openings in the vaulted roof; h the hearth-sole; i i holes in this; k a vaulted space under the hearth. The hearth has a suitable oval shape, and is covered with a flat arch. Its length is 16 feet, breadth 13½, mean height 2 feet.

Fig. 305, is a longitudinal section of the melting furnace; fig. 306, the ground plan, in which a is the fire door; b the grate; c the fire bridge; d the chimney; e the side openings; f the working doors; g the raking-out hole; h iron spouts, which conduct the melted metal into pits filled with water.

The melting furnace is altogether smaller; but its firing hearth is considerably larger

than in the roasting furnace. The long axis of the oval hearth is 14 feet; its short axis
10 feet; its mean height 2 feet.

300
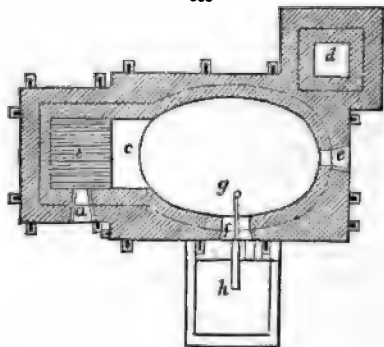
The principal ore smelted at Chessy is
the azure copper, which was discovered
by accident in 1812. Red copper ore, also,
has come into operation there since 1825.
The average metallic contents of the richest
azure ore are from 33 to 36 per cent.; of
the poorer, from 20 to 24. The red ore
contains from 40 to 67 parts in 100. The
ore is sorted, so that the mean contents of
metal may be 27 per cent., to which 20
per cent. of limestone are added; whence
the cinder will amount to 50 per cent. of
the ore. A few per cents. of red copper
slag, with some quicklime and *gahrslag*, are
added to each charge, which consists of
200 pounds of the above mixture, and
150 pounds of coke. When the furnace
(*fourneau à manche*, see the Scotch smelting hearth, under LEAD) is in good action,
from 10 to 14 such charges are worked in 12 hours. When the crucible is full of metal
at the end of this period, during which the cinder has been frequently raked off, the blast
is stopped, and the *matte* floating over the metal being sprinkled with water and taken
off, leaves the black copper to be treated in a similar way, and converted into *rosettes*.
The refining of this black copper is performed in a kind of reverberatory furnace.

The cinders produced in this reduction process are either vitreous and light blue,
which are most abundant; cellular, black, imperfectly fused from excess of lime; or,
lastly, red, dense, blistery, from defect of lime, from too much heat, and the passage of
protoxyde into the cinders. They consist of silicate of alumina, of lime, protoxyde of
iron; the red contain some silicate of copper.

307
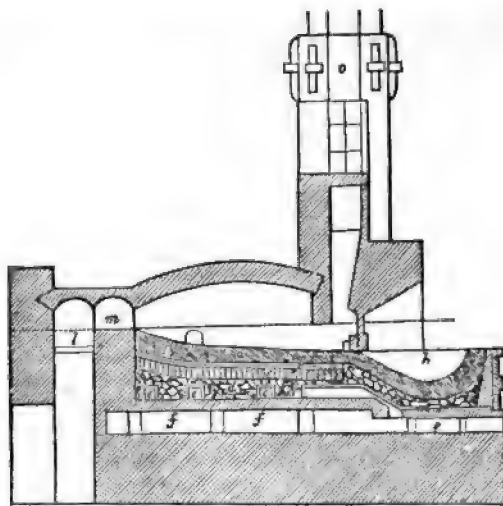
The copper-refining fur-
nace at Chessy, near Ly-
ons, is of the kind called
Spleiss-ofen (split hearths)
by the Germans.   *Fig.* 307
is a section lengthwise in
the dotted line A B of *fig.*
308, which is the ground
plan.

The foundation-walls are
made of gneiss; the arch,
the fire-bridge, and the
chimney, of fire-bricks. The
hearth, *a*, is formed of a
dense mixture of coal-dust,
upon a bottom of well-beat
clay, *b*, which reposes upon
a bed of brickwork *c*. Be-
neath this there is a slag
bottom *d*; *e* is the upper,
and *f* the under discharge
hole. The hearth is egg-
shaped; the longer axis be-
ing 8 feet, the shorter 6½
feet; in the middle it is 10
inches deep, and furnished with the outlets g g, which lead to each of the *Spleiss-hearths*
h h, fig. 308. These outlets are contracted with fire-bricks *i i*, till the proper period of
the discharge. The two hearths are placed in communication by a canal *k*: they are 3½
feet in diameter, 16 inches deep; are floored with well-beat coal ashes, and receive about
27 cwt. for a charge.

l is the grate; *m*, the fire-bridge; *n*, the boshes in which the *tuyères* lie; *o*, the
chimney; *p*, the working door through which the slags may be drawn off. Above
this is a small chimney, to carry off the flame and smoke whenever the door is
opened.

The smelting *post* or charge, to be purified at once, consists of 60 cwt. of black
copper, to which a little granular copper and copper of cementation is added; the

consumption of pit-coal amounts to 36 cwt. As soon as the copper is melted, the bellows are set a-going, and the surface of the metal gets soon covered with a

308
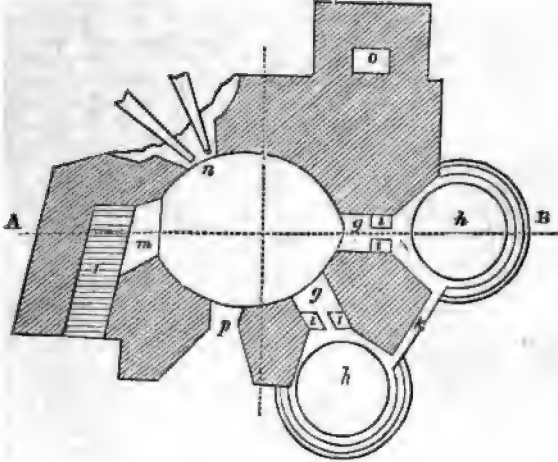
moderately thick layer of cinder, which is drawn off. This is the first skimming or *decrassage*. By and by, a second layer of cinder forms, which is in like manner removed; and this skimming is repeated, to allow the blast to act upon fresh metallic surfaces. After 4 or 5 hours, no more slag appears, and then the fire is increased. The melted mass now begins to boil or work (*travailler*), and continues so to do, for about ¾ of an hour, or an hour, after which the motion ceases, though the fire be kept up. The *gahrproof* is now taken; but the metal is seldom fine in less than ¾ of an hour after the boil is over. Whenever the metal is run off by the tap-hole into the two basins *i i*, called SPLIT-HEARTHS, a reddish vapor or mist rises from its surface, composed of an infinite number of minute globules, which revolve with astonishing velocity upon their axes, constituting what the Germans called *spratzen* (crackling) of the copper. They are composed of a nucleus of metal, covered with a film of protoxyde, and are used as sand for strewing upon manuscript. The copper is separated, as usual, by sprinkling water upon the surface of the melted metal, in the state of *rosettes*, which are immediately immersed in a stream of water. This refining process lasts about 16 or 17 hours; the skimmings weigh about 50 cwt.; the refuse is from 15 to 17 per cent.; the loss from 2 to 3 per cent. The *gahrslag* amounts to 11 cwt.

The refining of the eliquated copper (called *darrlinge*) from which the silver has been sweated out by the intervention of lead, can be performed only in small hearths. The following is the representation of such a furnace, called, in German, *Kupfergahrheerd*. Fig. 309 is the section lengthwise; *fig.* 310 is the section across; and *fig.* 311 is the
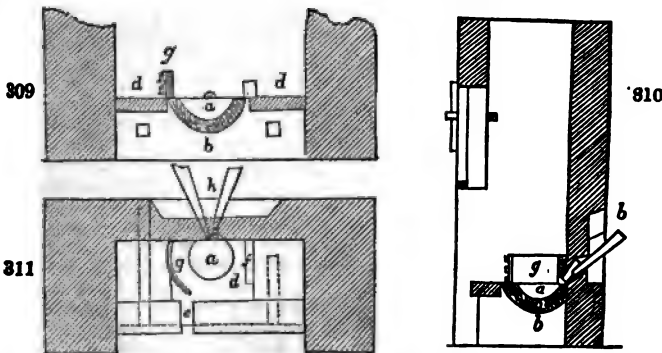
ground plan, in which *a* is the hearth-hollow; *b*, a massive wall; *c*, the mass out of which the hearth is formed; *d*, cast-iron plates covering the hearth; *e*, opening for

running off the liquid slag; *f*, a small wall; *g*, iron curb for keeping the coals together.

The hearth being heated with a bed of charcoal, ¾ cwt. of *darrlinge* are laid over it, and covered with more fuel: whenever this charge is melted, another layer of the coal and *darrlinge* is introduced, and thus in succession till the hearth become full, or contain from 2¼ to 2½ cwt. In Neustadt 7½ cwt. of *darrlinge* have been refined in one furnace, from which 5 cwt. of *gahrcopper* has been obtained. The blast oxydizes the foreign metals, namely, the lead, nickel, cobalt, and iron, with a little copper, forming the *gahrslag;* which is, at first, rich in lead oxyde, and poor in copper oxyde; but, at the end, this order is reversed. The slag, at first blackish, assumes progressively a copper red tint. The slag flows off spontaneously along the channel *e*, from the surface of the hearth. The *gahre* is tested by means of a proof-rod of iron, called *gahr-eisen*, thrust though the *tuyère* into the melted copper, then drawn out and plunged in cold water. As soon as the *gahrspan* (scale of copper) appears brownish red on the outside, and copper red within, so thin that it seems like a net-work, and so deficient in tenacity that it cannot be bent without breaking, the refining is finished. The blast is then stopped; the coals covering the surface, as also the cinders, must be raked off the copper, after being left to cool a little; the surface is now cooled by sprinkling water upon it, and the thick cake of congealed metal (*rondelle*) is lifted off with tongs, a process called *schleissen* (slicing), or *sheibenreissen* (shaving), which is continued till the last convex cake at the bottom of the furnace, styled the *kingspiece*, is withdrawn. These *rondelles* are immediately immersed in cold water, to prevent the oxydation of the copper; whereupon the metal becomes of a cochineal red color, and gets covered with a thin film of protoxyde. Its under surface is studded over with points and hooks, the result of tearing the congealed disc from the liquid metal. Such cakes are called *rosette* copper. When the metal is very pure and free from protoxyde, these cakes may be obtained very thin, one 24th of an inch for example.

The refining of two cwts. and a half of *darrlinge* takes three quarters of an hour, and yields one cwt. and a half of *gahrcopper* in 36 rosettes, as also some *gahrslag*. Gahr-copper generally contains from 1½ to 2½ per cent. of lead, along with a little nickel, silver, iron, and aluminum.

Smelting of the Mannsfeld copper schist, or bituminous Mergelschiefer.—The cupreous ore is first roasted in large heaps, of 2000 cwts., interstratified with brush-wood, and with some slates rich in bituminous matter, mixed with the others. These heaps are 3 ells high, and go on burning 15 weeks in fair and 20 in rainy weather. The bitumen is decomposed; the sulphur is dissipated chiefly in the form of sulphurous acid; the metal gets partially oxydized, particularly the iron, which is a very desirable circumstance towards the production of a good smelting slag. The calcined ore is diminished one tenth in bulk, and one eighth in weight; becoming of a friable texture and a dirty yellow gray color. The smelting furnaces are cupolas (*schachtofen*), 14 to 18 feet high; the fuel is partly wood charcoal, partly coke from the Berlin gas-works, and Silesia. The blast is given by cylinder bellows, recently substituted for the old barbarous *Blasebälgen*, or wooden bellows of the household form.

The cupreous slate is sorted, according to its composition, into slate of lime, clay, iron, &c., by a mixture of which the smelting is facilitated. For example, 1 post or charge may consist of 20 cwt. of the ferruginous slate, 14 of the calcareous, 6 of the argillaceous, with 3 of fluor spar, 3 of rich copper slags, and other refuse matters. The nozzle at the *tuyère* is lengthened 6 or 8 inches, to place the melting heat near the centre of the furnace. In 15 hours 1 fodder of 48 cwts. of the above mixture may be smelted, whereby 4 to 5 cwts. of *matte* (crude copper, called *Kupferstein* in Germany) and a large body of slags are obtained. The *matte* contains from 30 to 40 per cent. of copper, and from 2 to 4 *loths* (1 to 2 oz.) of silver. The slags contain at times one tenth their weight of copper.

The *matte* is composed of the sulphurets of copper, iron, silver, zinc, along with some arsenical cobalt and nickel. The slaty slag is raked off the surface of the melted *matte* from time to time. The former is either after being roasted six successive times, smelted into black copper; or it is subjected to the following concentration process. It is broken to pieces, roasted by brushwood and coals three several times in brick-walled kilns, containing 60 cwts., and turned over after every calcination; a process of four weeks' duration. The thrice roasted mass, called *spurrost*, being melted in the cupola *fig*. 313, with ore-cinder, yields the *spurstein*, or concentrated *matte*. From 30 to 40 cwts. of spurrost are smelted in 24 hours; and from 48 to 60 per cent. of *spurstein* are obtained, the slag from the slate smelting being employed as a flux. The spurstein contains from 50 to 60 per cent. of copper, combined with the sulphurets of copper, of iron, and silver.

The spurstein is now mixed with *dünnstein* (a sulphuret of copper and iron produced in the original smeltings) roasted six successive times, in the quantity of 60 cwts., with

brushwood and charcoal; a process which requires from 7 to 8 weeks. The product of this six-fold calcination is the *Gahrrost* of the Germans (done and purified); it has a color like red copper ore, varying from blue gray into cochineal red; a granular fracture; it contains a little of the metal, and may be immediately reduced into metallic copper, called *kupfermachen*. But before smelting the mass, it is lixiviated with water, to extract from it the soluble sulphate, which is concentrated in lead pans, and crystallized.

The lixiviated *gahröste* mixed with from $\frac{1}{4}$ to $\frac{1}{3}$ of the lixiviated *dünnsteinrost*, and $\frac{1}{6}$ to $\frac{1}{10}$ of the copper slate slag, are smelted with charcoal or coke fuel in the course of 24 hours, in a mass of 60 or 80 cwts. The product is black copper, to the amount of about $\frac{1}{4}$ the weight, and $\frac{1}{4}$ of *dünnstein* or *thin matte*. This black copper contains in the cwt. from 12 to 20 loths (6 to 10 oz.) of silver. The dünnstein consists of from 60 to 70 per cent. of copper combined with sulphur, sulphuret of iron, and arsenic; and when thrice roasted, yields a portion of metal. The black copper lies undermost in the crucible of the furnace; above it is the *dünnstein*, covered with the stone slag, or copper cinder, resulting from the slate-smelting. The slags being raked off, and the crucible sufficiently full, the eye or nozzle hole is shut, the *dünnstein* removed by cooling the surface and breaking the crust, which is about $\frac{1}{4}$ to $\frac{1}{3}$ inch thick. The same method is adopted for taking out the black copper in successive layers. For the de-silvering of this and similar black coppers, see SILVER.

313   312
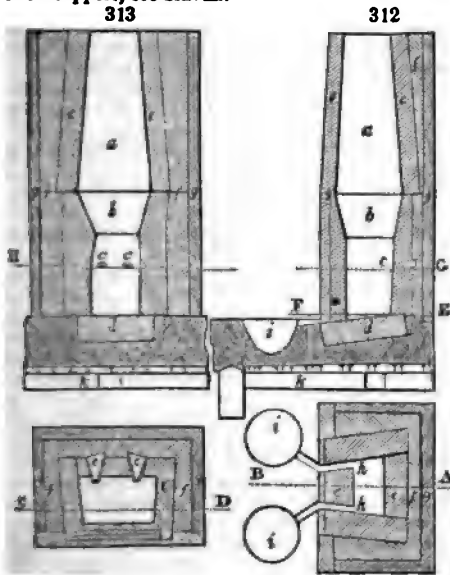
Fig. 312 is a vertical section through the form or *tuyère* in the dotted line A B of *fig.* 314. *Fig.* 313 is a vertical section in the dotted line C D of *fig.* 315. *a* is the shaft of the furnace, *b* the rest, *c c* the forms; *d* the sole or hearth-stone, which has a slope of 3 inches towards the front wall; *e e*, &c. casing walls of fire bricks; *f f*, &c. filling up walls built of rubbish stones; *g g* a mass through which the heat is slowly conducted; *h h* the two holes through one or other of which alternately the product of the smelting process is run off into the fore-hearth. Beneath the hearth-sole there is a solid body of loam; and the fore-hearth is formed with a mixture of coal-dust and clay; *k* is the discharge outlet. *Fig.* 314 is a horizontal section of the furnace through the hole or eye in the dotted line E F of *fig.* 312; *fig.* 315, a horizontal section of the shaft of the furnace through the form in the dotted line G H of *figs.* 312 and 313. The height of the shaft, from the line E F to the top, is 14 feet; from E to G, 25 inches; from *c* to the line below *b*, 2 feet; from that line to the line opposite *g g*, 2 feet. The width at the line *g g* is 3 feet 3 inches, and at *c* 26 inches. The basins *i i*, *fig.* 314, are 3 feet diameter, and 20 inches deep.

The refining of copper is said to be well executed at Seville, in Spain; and, therefore, some account of the mode of operating there may be acceptable to the reader.

The first object is to evaporate in a reverberatory furnace all the volatile substances, such as sulphur, arsenic, antimony, &c., which may be associated with the sulphur; and the second, to oxydize and to convert into scoriæ the fixed substances, such as iron, lead, &c., with the least possible expense and waste. The minute quantities of gold and silver which resist oxydation cannot be in any way injurious to the copper. The hearth is usually made of a refractory sand and clay with ground charcoal, each mixed in equal volumes, and worked up into a doughy consistence with water. This composition is beat firmly into the furnace bottom. But a quartzose hearth is found to answer better, and to be far more durable; such as a bed of fire-sandstone.

Before kindling the furnace, its inner surface is smeared over with a cream-consistenced mixture of fire-clay and water.

The cast pigs, or blocks of black or crude copper, are piled upon the hearth, each successive layer crossing at right angles the layer beneath it, in order that the flame may

have access to play upon the surface of the hearth, and to heat it to a proper pitch for making the metal flow.

The weight of the charge should be proportional to the capacity of the furnace, and such that the level of the metallic bath may be about an inch above the nozzle of the bellows; for, were it higher, it would obstruct its operation, and were it too low, the stream of air would strike but imperfectly the surface of the metal, and would fail to effect, or would retard at least, the refining process, by leaving the oxydation and volatilization of the foreign metals incomplete.

As the scoriæ form upon the surface, they are drawn off with an iron rabble fixed to the end of a wooden rod.

Soon after the copper is melted, charcoal is to be kindled in three iron basins lined with loam, placed alongside the furnace, to prepare them for receiving their charge of copper, which is to be converted in them, into *rosettes*.

The bellows are not long in action before the evaporation of the mineral substances is so copious, as to give the bath a boiling appearance; some drops rise up to the roof of the reverberatory, others escape by the door, and fall in a shower of minute spherical globules. This phenomenon proves that the process is going on well; and, when it ceases, the operation is nearly completed. A small proof of copper, of the form of a watch-case, and therefore called *montre*, is taken out from time to time, upon the round end of a polished iron rod, previously heated. This rod is dipped two or three inches into the bath, then withdrawn and immersed in cold water. The copper cap is detached from the iron rod, by a few blows of a hammer; and a judgment is formed from its thickness, color, and polish, as to the degree of purity which the copper has acquired. But these *watches* need not be drawn till the small rain, above spoken of, has ceased to fall. At the end of about 11 hours of firing, the numerous small holes observable in the first *watch* samples begin to disappear; the outer surface passes from a bright red to a darker hue, the inner one becomes of a more uniform color, and always less and less marked with yellowish spots. It will have acquired the greatest pitch of purity that the process can bestow, when the *watches* become of a dark crimson color.

Care must be taken to stop this refining process at the proper time; for, by prolonging it unduly, a small quantity of cupreous oxyde would be formed, which, finding no oxygen to reduce it, would render the whole body of copper hard, brittle, and incapable of lamination.

The basins must now be emptied of their burning charcoal, the opening of the *tuyère* must be closed, and the melted copper allowed to flow into them through the tap-hole, which is then closed with loam. Whenever the surface is covered with a solid crust, it is bedewed with water; and as soon as the crust is about $1\frac{1}{2}$ inch thick it is raised upon hooks above the basin, to drain off any drops, and then carried away from the furnace. If these cakes, or rosettes, be suddenly cooled by plunging them immediately in water, they will assume a fine red color, from the formation of a film of oxyde.

Each refining operation produces, in about 12 hours, $1\frac{7}{10}$ tons of copper, with the consumption of about $\frac{4}{5}$ of a ton of dry wood.

Care should be taken that the copper cake or *rosette* be all solidified before plunging it into water, otherwise a very dangerous explosion might ensue, in consequence of the sudden extrication of oxygen from the liquid metal, in the act of condensation. On the other hand, the cake should not be allowed to cool too long in the air, lest it get peroxydized upon the surface, and lose those fine red, purple, and yellow shades, due to a film of the protoxyde, which many dealers admire.

When a little oxyde of antimony and oxyde of copper are combined with copper, they occasion the appearance of micaceous scales in the fractured faces. Such metal is hard, brittle, yellowish within, and can be neither laminated nor wire-drawn. These defects are not owing to arsenic, as was formerly imagined; but, most probably, to antimony in the lead, which is sometimes used in refining copper. They are more easily prevented than remedied.

According to M. Frèrejean, proprietor of the great copper works of Vienne, in Dauphiny, too low a temperature, or too much charcoal, gives to the metal a cubical structure, or that of divergent rays; in either of which states it wants tenacity. Too high a temperature, or too rapid a supply of oxygen, gives it a brick red color, a radiated crystallization without lustre, or a very fine grain of indeterminate form; the last structure being unsuitable for copper that is to be worked under the hammer or in the rolling-press. The form which indicates most tenacity is radiated with minute fibres glistening in mass. Melted copper will sometimes pass successively through these three states in the space of ten minutes.

Fig. 316 represents a *roasting mound* of copper pyrites in the Lower Hartz, near Goslar, where a portion of the sulphur is collected. It is a vertical section of a truncated quadrangular pyramid. A layer of wooden billets is arranged at the base of the pyramid in the line *a a.*

c, a wooden chimney which stands in the centre of the mound with a small pile of arcoal at its bottom, c; *d d* are large lumps of ore surrounded by smaller pieces; *f f* are rubbish and earth to form a covering. A current of air is admitted under the billets by an opening in the middle of each of the four sides of the base *a a*, so that two principal currents of air cross under the vertical axis c of the truncated pyramid, as indicated in the figure.
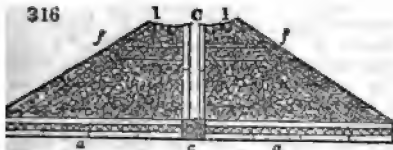
The fire is applied through the chimney c; the charcoal at its bottom c, and the piles *a* are kindled. The sulphureous ores, *d f*, are raised to such a high temperature as expel the sulphur in the state of vapor.

In the Lower Hartz a roasting mound continues burning during four months. Some ays after it is kindled the sulphur begins to exhale, and is condensed by the air at the pper surface of the pyramid. When this seems impregnated with it, small basins 1 1 e excavated, in which some liquid sulphur collects; it is removed from time to time ith iron ladles, and thrown into water, where it solidifies. It is then refined and cast to roll brimstone.

A similar roasting mound contains, in the Lower Hartz, from 100 to 110 tons of ore nd 730 cubic feet of wood. It yields in four months about one ton and a half of ilphur from copper pyrites. Lead ore is treated in the same way, but it furnishes less ilphur.

There are usually from 12 to 15 roasting heaps in action at once for three smelting orks of the Lower Hartz. After the first roasting two heaps are united to form a third, hich is calcined anew, but under a shed; the ores are then stirred up and roasted for e third time, whence a crude mixture is procured for the smelting-house.

The most favorable seasons for roasting in the open air are spring and autumn; the st weather is a light wind accompanied with gentle rain. When the wind or rain structs the operation, this inconvenience is remedied by planks distributed round the pper surface of the truncated pyramid over the sulphur basins.

Manufacturing assays of copper.—The first thing is to make such a sample as will present the whole mass to be valued; with which view, fragments must be taken from fferent spots, mixed, weighed, and ground together. A portion of this mixture being ied by the blow-pipe, will show, by the garlic or sulphurous smell of its fumes, whether senic, sulphur, or both, be the mineralizers. In the latter case, which often occurs, 0 gr. or 1000 gr. of the ore are to be mixed with one half its weight of saw-dust, en imbued with oil, and heated moderately in a crucible till all the arsenical fumes be sipated. The residuum, being cooled and triturated, is to be exposed in a shallow rthen cup to a slow roasting heat, till the sulphur and charcoal be burned away. What mains, being ground and mixed with half its weight of calcined borax, one twelfth its eight of lamp black, next made into a dough with a few drops of oil, is to be pressed wn into a crucible, which is to be covered with a luted lid, and to be subjected, in a rwerful air furnace, first to a dull red heat, and then to vivid ignition for 20 minutes. a cooling and breaking the crucible, a button of metallic copper will be obtained. Its lor and malleability indicate pretty well the quality, as does its weight the relative lue of the ore. It should be cupelled with lead, to ascertain if it contains silver or ld. See ASSAY, and SILVER.

If the blow-pipe trial showed no arsenic, the first calcination may be omitted; and if sither sulphur nor arsenic, a portion of the ground ore should be dried, and treated reetly with borax, lamp-black, and oil. It is very common to make a dry assay of pper ores, by one roasting and one fusion along with 3 parts of black flux; from the eight of the metallic button the richness of the ore is inferred.

The humid assay is more exact, but it requires more skill and time.

The sulphur and the silica are easily got rid of by the acids, which do not dissolve em, but only the metallic oxydes and the other earths. These oxydes may then be rown down by their appropriate reagents, the copper being precipitated in the state of ther the black oxyde or pure metal. 105 parts of black oxyde represent 100 of copper. efore entering upon the complete analysis of an ore, preliminary trials should be made, ascertain what are its chief constituents. If it be sulphuret of copper, or copper yrites, without silver or lead, 100 grains exactly of its average powder may be weighed ut, treated in a matrass with boiling muriatic acid for some time, gradually adding a few rops of nitric acid, till all action ceases, or till the ore be all dissolved. The insoluble atter found floating in the liquid contains most of the sulphur; it may be separated on a filter, washed, dried, and weighed; then verified by burning away. The incombustible residuum, treated by muriatic acid, may leave an insoluble deposite, which is o be added to the former. To the whole of the filtered solutions carbonate of potash is

to be added; and the resulting precipitate, being washed, and digested repeatedly in water of ammonia, all its cupric oxyde will have been dissolved, whenever the ammonia is no longer rendered blue.

Caustic potash, boiled with the ammoniacal solution, will separate the copper in the state of black oxyde; which is to be thrown upon a filter, washed, dried, and weighed. The matter left undissolved by the ammonia, consists of oxyde of iron, with probably a little alumina. The latter being separated by caustic potash, the iron oxyde may be also washed, dried, and weighed. The powder which originally resisted the muriatic acid, is silica.

Assay of copper ores, which contain iron, sulphur, silver, lead, and antimony.

100 grains of these ores, previously sampled, and pulverized, are to be boiled with nitric acid, adding fresh portions of it from time to time, till no more of the matter be dissolved. The whole liquors which have been successively digested and decanted off, are to be filtered and treated with common salt, to precipitate the silver in the state of a chloride.

The nitric acid, by its reaction upon the sulphur, having generated sulphuric acid, this will combine with the lead oxydized at the same time, constituting insoluble sulphate of lead, which will remain mixed with the gangue. Should a little nitrate of lead remain in the liquid, it may be thrown down by sulphate of soda, after the silver has been separated. The dilute liquid, being concentrated by evaporation, is to be mixed with ammonia in such excess as to dissolve all the cupric oxyde, while it throws down all the oxyde of iron and alumina; which two may be separated, as usual, by a little caustic potash. The portion of ore insoluble in the nitric acid being digested in muriatic acid, everything will be dissolved except the sulphur and silica. These being collected upon a filter, and dried, the sulphur may be burned away, whereby the proportion of each is determined.

Ores of the oxyde *of copper* are easily analyzed by solution in nitric acid, the addition of ammonia, to separate the other metals, and precipitation by potash. The *native carbonate* is analyzed by calcining 100 grains; when the loss of weight will show the amount of water and carbonic acid; then that of the latter may be found, by expelling it from another 100 grains, by digestion in a given weight of sulphuric acid. The copper is finally obtained in a metallic state by plunging bars of zinc into the solution of the sulphate.

The *native arseniates of copper* are analyzed by drying them first at a moderate heat; after which they are to be dissolved in nitric acid. To this solution, one of nitrate of lead is to be added, as long as it occasions a precipitate; the deposite is to be drained upon a filter, and the clear liquid which passes through, being evaporated nearly to dryness, is to be digested in hot alcohol, which will dissolve everything except a little arseniate of lead. This being added to the arseniate first obtained, from the weight of the whole, the arsenic acid, constituting 35 per cent., is directly inferred. The alcoholic solution being now evaporated to dryness, the residue is to be digested in water of ammonia, when the cupric oxyde will be dissolved, and the oxyde of iron will remain. The copper is procured, in the state of black oxyde, by boiling the filtered ammoniacal solution with the proper quantity of potash.

*The analysis of muriate of copper—atacamite—*is an easy process. The ore being dissolved in nitric acid, a solution of nitrate silver is added, and from the weight of the chloride precipitated, the equivalent amount of muriate or chloride of copper is given; for 100 of chloride of silver represent 93 of chloride of copper, and 43·8 of its metallic basis. This calculation may be verified by precipitating the copper of the muriate from its solution in dilute sulphuric acid, by plates of zinc.

The phosphate of copper may be analyzed either by solution in nitric acid, and precipitation by potash; or by precipitating the phosphoric acid present, by means of acetate of lead. The phosphate of lead thus obtained, after being washed, is to be decomposed by dilute sulphuric acid. The insoluble sulphate of lead, being washed, dried, and weighed, indicates by its equivalent the proportion of phosphate of lead, as also of phosphate of copper; for 100 of sulphate of lead correspond to 92·25 phosphate of lead, and 89·5 phosphate of copper; and this again to 52·7 of the black oxyde.

Copper forms the basis of a greater number of important ALLOYS than any other metal. With zinc, it forms Brass in all its varieties; which see.

BRONZE and BELL METAL are alloys of copper and tin. This compound is prepared in crucibles when only small quantities are required; but in reverberatory hearths, when statues, bells, or cannons are to be cast. The metals must be protected as much as possible during their combination from contact of air by a layer of pounded charcoal, otherwise two evils would result, waste of the copper by combustion, and a rapid oxydizement of the tin, so as to change the proportions and alter the properties of the alloy. The fused materials ought to be well mixed by stirring, to give uniformity to the compound. See BRONZE.

100 of copper and 4·17 of tin has been proposed by M. Chaudet for the
cture of *medals*. After melting this alloy, he casts it in moulds made of
as is used for cupels. The medals are afterward subjected to the action
press, not for striking them, for the mould furnishes perfect impressions,
ng and polishing them.

t analysis of M. Berthier, the bells of the *pendules*, or ornamental clocks,
, are found to be composed—of copper 72·00, tin 26·56, iron 1·44, in 100

100 of copper and 14 of tin is said by M. Dussaussy to furnish tools, which,
sharpened in the manner of the ancients, afford an edge nearly equal to

ongs, and the *tamtam* of the Chinese are made of an alloy of 100 of copper
i of tin. To give this compound the sonorous property in the highest de-
be subjected to sudden refrigeration. M. D'Arcet, to whom this discovery
mends to ignite the piece after it is cast, and to plunge it immediately into
The sudden cooling gives the particles of the alloy such a disposition,
:gulated pressure by skilful hammering, they may be made to slide over each
nain permanently in their new position. When by this means the instru-
:ived its intended form, it is to be heated and allowed to cool slowly in the
rticles now take a different arrangement from what they would have done
frigeration; for instead of being ductile, they possess such an elasticity,
; displaced by a slight compression, they return to their primary position
of extremely rapid vibrations; whence a very powerful sound is emitted.
netal, and probably all the other alloys of tin with copper, present the same

If 100 of copper with from 60 to 33 of tin forms common *bell-metal*. It is
whitish gray, brittle, and sonorous, but not so much so as the preceding.
house-clock bells contains a little more tin than that of church-bells, and the
ater contains a little zinc in addition to the other ingredients.
:-founder should study to obtain a rapid fusion, in order to avoid the causes
:ated above. Reverberatory furnaces have been long adopted for this opera-
ong these, the elliptical are the best. The furnaces with spheroidal domes
he bell-founders, because their alloy being more fusible, a more moderate
is required; however, as the rapidity of the process is always a matter of
they also would find advantage in employing the elliptical hearths, (*see the
melting furnace, as figured under Smelting of copper ores.*) Coal is now
referred for fuel.
of 100 of copper with 50 of tin, or more exactly of 32 of the former with
ter, constitutes *speculum* metal, for making mirrors of reflecting telescopes.
id is nearly white, very brittle, and susceptible of a fine polish with a bril-
The following compound is much esteemed in France for making specula.
of pure copper and 1 of grain-tin in separate crucibles, incorporate thor-
, wooden spatula, and then run the metal into moulds. The lower surface
t should be worked into a mirror.
ds, in the Nautical Almanack for 1787, gave the following instructions for
lum metal.
· of the copper is to be tried by making a series of alloys with tin, in the pro-
) of the former to 47, to 48, to 49, and to 50 of the latter metal; whence
is of the whitest compound may be ascertained. Beyond the last proportion,
ns to lose in brilliancy of fracture, and to take a bluish tint. Having deter-
int, take 32 parts of the copper, melt, and add one part of brass and as much
ig the surface of the mixture with a little black flux; when the whole is
ith a wooden rod, and pour in from 15 to 16 parts of melted tin (as indica-
eparatory trials), stir the mixture again, and immediately pour it out into
Then melt again at the lowest heat, adding for every 16 parts of the com-
of white arsenic, wrapped in paper, so that it may be thrust down to the
: crucible. Stir with a wooden rod as long as arsenical fumes rise, and then
, sand mould. While still red hot, lay the metal in a pot-full of very hot em-
may cool very slowly, whereby the danger of its cracking or flying into
revented.
icribed the different alloys of copper and tin, I shall now treat of the method
these metals from each other as they exist in old cannons, damaged bells,
ocess employed on a very great scale in France, during the Revolution, for
per from bells, was contrived by Fourcroy; founded upon the chemical fact
are fusible and oxydizable than copper.
in quantity of bell-metal was completely oxydized by calcination in a rever-
ace; the oxyde was raked out, and reduced to a fine powder.
i same furnace a fresh quantity of the same metal was introduced; it was

melted, and there was added to it one half of its weight of the oxyde formed in the first operation. The temperature was increased, and the mixture well incorporated; at the end of a few hours, there was obtained on the one hand copper almost pure, which subsided in a liquid state, and spread itself upon the sole of the hearth, while a compound of oxyde of tin, oxyde of copper, with some of the earthy matters of the furnace, collected on the surface of the metallic bath in a pasty form. These scoriæ were removed with a rake, and as soon as the surface of the melted copper was laid bare, it was run out. The scoriæ were levigated, and the particles of metallic copper were obtained after elutriation. By this process, from 100 pounds of bell-metal, about 50 pounds of copper were extracted, containing only one *per cent.* of foreign matters.

3. The washed scoriæ were mixed with ½ their weight of pulverized charcoal; the mixture was triturated to effect a more intimate distribution of the charcoal; and it was then put into a reverberatory hearth, in which, by aid of a high heat, a second reduction was effected, yielding a fluid alloy consisting of about 60 parts of copper and 20 of tin; while the surface of the bath got covered with new scoriæ, containing a larger proportion of tin than the first.

4. The alloy of 60 of copper with 40 of tin was next calcined in the same reverberatory furnace, but with stirring of the mass. The air, in sweeping across the surface of the bath, oxydized the tin more rapidly than the copper; whence proceeded crusts of oxyde that were skimmed off from time to time. This process was continued till the metallic alloy was brought to the same standard as bell-metal, when it was run out to be subjected to the same operations as the metal of No. 1.

The layers of oxyde successively removed in this way were mixed with charcoal, and reduced in a *fourneau à manche,* or Scotch lead smelting furnace.

I shall not prosecute any further the details of this complicated process of Fourcroy; because it has been superseded by a much better one contrived by M. Bréant. He employed a much larger quantity of charcoal to reduce the scoriæ rich in tin; and increased the fusibility by adding crushed oyster-shells, bottle glass, or even vitrified scoriæ, according to the nature of the substance to be reduced; and he treated them directly in a reverberatory furnace.

The metal, thus procured, was very rich in tin. He exposed it in masses on a sloping hearth of a reverberatory furnace, where, by a heat regulated according to the proportions of the two metals in the alloy, he occasioned an eliquation or sweating out of the tin. Metallic drops were seen to transpire round the alloyed blocks or pigs, and, falling like rain, flowed down the sloping floor of the furnace; on whose concave bottom the metal collected, and was ladled out into moulds. When the alloy, thus treated, contained lead, this metal was found in the first portions that sweated out. The purest tin next came forth, while the last portions held more or less copper in solution. By fractioning the products, therefore, there was procured—

1. Tin with lead.
2. Tin nearly pure.
3. Tin alloyed with a little copper.

A spongy mass remained, exhibiting sometimes beautiful crystallizations; this mass, commonly too rich in copper to afford tin by liquation, was treated by oxydizement. In this manner, M. Bréant diminished greatly the reductions and oxydations; and therefore incurred in a far less degree the enormous waste of tin, which flies off with the draught of air in high and long-continued heats. He also consumed less fuel as well as labor, and obtained purer products of known composition, ready to be applied directly in many arts.

He treated advantageously in this manner more than a million of kilogrammes (1000 tuns) of scoriæ, for every 2 cwts. of which he paid 40 *centimes* (four-pence), while several million kilogrammes of much richer scoriæ had been previously sold to other refiners at 5 *centimes* or one *sous.*

I have said that the ancients made their tools and military weapons of Bronze. Several of these have been analyzed, and the results are interesting.

An antique sword, found in 1799, in the peat moss of the Somme, consisted of copper 87·47; tin 12·53, in 100 parts.

The bronze springs for the balistæ, according to Philo of Byzantium, were made of copper 97, tin 3.

Hard and brittle nails afforded by analysis, 92 of copper, and 8 of tin.

Of three antique swords found in the environs of Abbeville, one was found to consist of 85 of copper to 15 of tin. The nails of the handle of this sword were flexible; they were composed of copper 95, tin 5.

Another of the swords consisted of 90 of copper and 10 of tin; and the third, of 96 copper, with 4 tin.

A fragment of an ancient scythe afforded to analysis 92·6 copper, and 7·4 tin.

The process of coating copper with tin, exemplifies the strong affinity between the two metals. The copper surface to be tinned is first cleared up with a smooth sand-

e; then it is heated and rubbed over with a little sal ammoniac, till it be perfectly
a and bright: the tin, along with some pounded rosin, is now placed on the copper,
ch is made so hot as to melt the tin, and allow of its being spread over the surface with
sail or pad of tow. The layer thus fixed on the copper is exceedingly thin; Bayen
d that a copper pan, 9 inches in diameter and 3½ inches deep, being weighed imme-
ly before and after tinning, became only 21 grains heavier. Now as the area tinned,
ding the bottom, amounted to 155 square inches, 1 grain of tin had been spread over
rly 7½ square inches; or only 20 grains over every square foot.

opper and Arsenic form a white-colored alloy, sometimes used for the scales of
mometers and barometers; for dials, candlesticks, &c. To form this compound, suc-
ive layers of copper clippings and white arsenic are put into an earthen crucible;
ch is then covered with sea salt, closed with a lid, and gradually heated to redness.
! parts of arsenic have been used with 5 of copper, the resulting compound com-
ly contains one tenth of its weight of metallic arsenic. It is white, slightly
ile, denser, and more fusible than copper, and without action on oxygen at ordinary
peratures; but, at higher heats, it is decomposed with the exhalation of arsenious
. The white copper of the Chinese consists of 40·4 copper; 31·6 nickel; 25·4
·; and 2·6 iron. This alloy is nearly silver white; it is very sonorous, well
shed, malleable at common temperatures, and even at a cherry red, but very brittle
a red-white heat. When heated with contact of air, it oxydizes, burning with a
te flame. Its specific gravity was 8·432. When worked with great care, it may
reduced to thin leaves, and to wires as small as a needle. See GERMAN SILVER,
.

atenag, formerly confounded with white copper, is a different composition from the
re. Keir says it is composed of copper, zinc, and iron; and Dick describes it as a
t metal, of a grayish color, and scarcely sonorous. The Chinese export it, in large
atities, to India.

OPPER, WHITE, or *German silver.* M. Gersdorf, of Vienna, states, that the propor-
s of the metals in this alloy should vary according to the uses for which it is destined.
m intended as a substitute for silver, it should be composed of 25 parts of nickel, 25
ine, and 50 of copper. An alloy better adapted for rolling, consists of 25 of nickel,
f zinc, and 60 of copper. Castings, such as candlesticks, bells, &c., may be made
a alloy, consisting of 20 of nickel, 20 of zinc, and 60 of copper; to which 3 of lead
sdded. The addition of 2 or 2½ of iron (in the shape of tin plate ?) renders the pack-
· much whiter, but, at the same time, harder and more brittle.

eferstein has given the following analysis of the genuine German silver, as made from
original ore found in Hildburghausen, near Suhl, in Henneberg :—

Copper	-	-		-	40·4
Nickel	-	-	-	-	- 31·6
Zinc		-	-	-	- 25·4
Iron	-	-	-	-	- 2·6
					100·0

hinese packfong, according to the same authority, consists of 5 parts of copper, alloy-
rith 7 parts of nickel, and 7 parts of zinc.

he best alloy for making plummer blocks, bushes, and steps for the steel or iron gud-
is and pivots of machinery to run in, is said to consist of 90 parts of copper, 5 of
, and 5 of antimony.

factitious protoxyde of copper, of a fine red color, may be made by melting together,
a gentle heat, 100 parts of sulphate of copper, and 59 of carbonate of soda in crys-
, and continuing the heat till the mass become solid. This being pulverized and
ed exactly with 15 parts of copper filings, the mixture is to be heated to whiteness, in
ucible, during the space of 20 minutes. The mass, when cold, is to be reduced to
der, and washed. A beautiful metallic pigment may be thus prepared, at the cost
. a pound.

ll the oxydes and salts of copper are poisonous; they are best counteracted by ad-
istering a large quantity of sugar, and sulphureted hydrogen water.

he following scientific summary of copper ores in alphabetical order may prove ac-
able to many readers, amid the present perplexing distribution of the native metallic
pounds in mineralogical systems.

, *Arseniate of Copper.*

. *Erinite*, rhomboidal arseniate of copper, micaceous copper, *kupferglimmer.*
rald green: specific gravity 4·043; scratches calc-spar; yields water by heat;
ble at the blowpipe, and reducible into a white metallic globule. Soluble in nitric
; the solution throws down copper by iron. It consists of arsenic acid 33·78;
le of copper 59·24; water 5; alumina 1·77. It is found in Cornwall, Ireland,
gary.

. *Liroconite;* octahedral arseniate of copper; lens ore, so called from the flatness

of the crystal. Blue; specific gravity 2·88; scratches calc-spar. It consists of arsenic acid 14; oxyde of copper 49; water 35. It is found in Huel-Mutrel, Huel-Gorland, Huel-Unity, mines in Cornwall.

C.   *Olivenite;* right prismatic arseniate of copper; olive-ore. Dull green; specific gravity 4·28; scratches fluor; yields no water by heat; fusible at the blowpipe into a glassy bead, enclosing a white metallic grain. It consists of arsenic acid 45, oxyde of copper 50·62. It affords indications of phosphoric acid, which the analysts seem to have overlooked. It occurs in the above and many other mines in Cornwall.

D.   *Aphanese.* Trihedral arseniate of copper. Bluish green, becoming gray upon the surface; specific gravity 4·28; scarcely scratches calc-spar; yields water with heat; and traces of phosphoric acid.

The fibrous varieties called wood copper, contain water, and resemble the last species in composition.

2.   *Carbonate of Copper.*

A.   *Azurite;* kupferlazur. Blue. Crystallizes in oblique rhomboidal prisms; specific gravity 3 to 3·83; scratches calc-spar, is scratched by fluor; yields water with heat, and blackens. Its constituents are, carbonic acid 25·5; oxyde of copper 69·1; water 5·4. The Chessy and Banat azurite is most profitably employed to make sulphate of copper.

B.   *Malachite;* green carbonate or mountain green. Crystallizes in right rhomboidal prisms; specific gravity 3·5; affords water with heat, and blackens. It consists of carbonic acid 18·5; oxyde of copper 72·2; water 9·3.

C.   *Mysorine;* anhydrous carbonate of copper. Dark brown generally stained green or red; conchoidal fracture; soft, sectile; specific gravity 2·62. It consists of carbonic acid 16·7; oxyde of copper 60·75; peroxyde of iron 19·5; silica 2·10. This is a rare mineral found in the Mysore.

3.   *Chromate of Copper and Lead;* vauquelinite.   Green of various shades; specific gravity 6·8 to 7·2; brittle; scratched by fluor; fusible at the blowpipe with froth and the production of a leaden bead. It consists of chromic acid 28·33; oxyde of lead 60·87; oxyde of copper 10·8. It occurs at Berezof in Siberia along with chromate of lead.

4.   *Dioptase;* silicate of copper; emerald copper.   Specific gravity 3·3; scratches glass with difficulty; affords water with heat, and blackens; infusible at the blowpipe. It consists of silica 43·18; oxyde of copper 45·46; water 11·36. This rare substance comes from the government of Kirgis.

The silicate of Dillenberg is similar in composition.

5.   Gray copper ore called Panabase, from the number of metallic bases which it contains; and Fahlerz. Steel gray; specific gravity 4·79 to 5·10; crystallizes in regular tetrahedrons; fusible at the blowpipe, with disengagement of fumes of antimony and occasionally of arsenic; swells up and scorifies, affording copper with soda flux. Is acted upon by nitric acid with precipitation of antimony; becomes blue with ammonia; yields a blue precipitate with ferrocyanide of potassum; as also indications frequently of zinc, mercury, silver, &c. Its composition which is very complex is as follows: sulphur 26·83; antimony 12·46; arsenic 10·19; copper 40·60; iron 4·66; zinc 3·69; silver 0·60. Some specimens contain from 5 to 31 per cent. of silver. The gray copper ores are very common; in Saxony; the Hartz; Cornwall; at Dillenberg; in Mexico; Peru, &c. They are important on account both of their copper and silver. *Tennantite* is a variety of Fahlerz. It occurs in Cornwall. Its constituents are, sulphur 28·74; arsenic 11·84; copper 45·32; iron 9·26.

6.   *Hydrated silicate of Copper;* or Chrysocolla.   Green or bluish green; specific gravity 2·03 to 2·16; scratched by steel; very brittle; affords water with heat, and blackens; is acted upon by acids, and leaves a silicious residuum.   Solution becomes blue with ammonia. Its constituents are silica 26; oxyde of copper 50; water 17; carbonic acid 7.

7.   *Muriate of Copper.* Gtakamite; green; crystallizes in prisms; specific gravity 4·43.   Its constituents are, chlorine 15·90; copper 14·22; oxyde of copper 54·22; water 14·16; oxyde of iron 1·50. The green sand of Peru, collected by the inhabitants of Atakama, is this substance in a decomposed state.

8.   *Oxyde of Copper.*

A.   Black, or Melaconise; a black earthy looking substance found at Chessy and other places. It is deutoxyde of copper.

B.   Protoxyde or red oxyde of copper; ziegelerz. Crystallizes in the regular octahedron; specific gravity 5·69; scratches calc-spar; fusible at the blowpipe into the black oxyde; and reducible in the smoke of the flame to copper; acted upon by nitric acid with disengagement of nitrous gas; solution is rendered blue by ammonia. Its constituents are oxygen 11·22; copper 88·78. It occurs near Chessy, and upon the eastern slope of the Altai mountains.

9.   *Phosphate of Copper.* Dark green; crystallizes in octahedrons; specific gravity 3·6 to 3·8; scratches calc-spar; yields water with heat; and affords metallic copper

with soda flux; acted on by nitric acid. Its constituents are, phosphoric acid 28·7; oxyde of copper 63·9; water 7·4. It occurs at the mines of Libethen in Hungary.

10. *Pyritous Copper;* Kupferkies; a metallic looking substance, of a bronze-yellow color, crystallizing in octahedrons which pass into tetrahedrons; specific gravity 4·16; fusible at the blowpipe into beads attractable by the magnet, and which afterwards afford copper with a soda flux; soluble in nitric acid; solution is rendered blue by ammonia, and affords an abundant precipitate of iron. Its composition is, sulphur 36; copper 34·5; iron 30·5; being a combined sulphuret of these two metals. This is the most important metallurgic species of copper ores. It occurs chiefly in primitive formations, as among gneiss and mica slate, in veins, or more frequently masses, in very many parts of the world—Cornwall, Anglesea, Wicklow, &c. It is found among the early secondary rocks, in Shetland, Yorkshire, Mannsfeldt,.&c. The finest crystallized specimens come from Cornwall, Derbyshire, Freyberg, and Saint Marie-aux-Mines in France.

11. *Seleniate of Copper;* Berzeline. Is of metallic aspect; silver white; ductile; fusible at the blowpipe into a gray bead, somewhat malleable; is acted upon by nitric acid; consists of selenium 40; copper 64.

12. *Sulphate of Copper;* Cyanose. Blue; soluble, &c. like the artificial sulphates, which see.

Brochantite is a subsulphate of copper, observed in small crystals at Ekaterinenbourg in Siberia.

13. *Sulphuret of Copper;* Kupferglanz. Of a steel gray metallic aspect; crystallizes in rhomboids; specific gravity 5·69; somewhat sectile, yet brittle; fusible with intumescence at the blowpipe, and yields a copper bead with soda; soluble in nitric acid; becomes blue with ammonia, but lets fall scarcely any oxyde of iron. Its constituents are sulphur 19; copper 79·5; iron 0·75; silica 1·00. It occurs in small quantities in Cornwall, &c.

The chemical preparations of copper which constitute distinct manufactures are, Blue or Roman vitriol; for which see *Sulphate of Copper;* Scheele's green and Schweinurth green, Verditer, and Verdigris. See these articles in their alphabetical places.

COPPER, *Statistics of.*—Copper ores may be imported into Great Britain for smelting, from any country, and under any flag. On arrival of the cargo at Swansea or elsewhere, a bond is given at the Custom-house, which binds the party to return the quantity of copper which the lot of ores shall be ascertained to contain, into bond within a limited period, or pay thereon the duty as foreign copper, which is 27*l.* per ton. The cargo of ore is then weighed out by the custom-house officer, and samples are taken, which are sent to two assay-masters in Cornwall, the highest produce of the two being entered as that of the cargo. This fixes the quantity of copper that must be exported under the bond.

The copper produced from foreign ores must then find a market, as cake or pig copper, in France, Holland, Germany, Italy, the United States of America, &c. At Calcutta, it is subject to a duty of 6 per cent.; and at Bombay, to a duty of 10 per cent. *ad valorem.*

The export of British unwrought copper to the continent of Europe, and to the United States of America, was formerly inconsiderable. These countries drew the bulk of their supplies either from the north of Europe, or direct from South America in pig copper. In point of fact, the copper derived from the import of foreign ores for smelting has produced for itself a new market, as the following table, taken from the official returns, will show.

Export of unwrought copper from Great Britain to all parts, except Asia :—

Years ending January 5,	1830	881 tons.
—	1831	857 —
—	1832	1326 —
—	1833	2471 —
—	1834	2523 —
—	1835	3267 —
—	1836	4083 —
—	• 1837	2546 —

In the last year, that ended with 5th January, 1838, the export of unwrought copper was about 5000 tons.

Let any candid and practical man consider attentively this table, and compare it with the import of foreign ores for the same period, and with the gradual advance in the value of copper; and then let him, if he can, avoid the conclusion that the admission of foreign ores for smelting was a great boon conferred upon the British copper mines, for it made this country what it now is, the regulator and distributor of the copper produce of the world—the country to which all others consuming and not producing copper, must look for a regular, certain, and economical supply. We want the admission merely under proper and safe regulations, of foreign copper for refining, to draw to this country

:he whole supply of copper for the world, by which prices would be regulated and main tained, and our copper-mining interests put beyond the reach of successful rivalry.

This country did not furnish any supply of unwrought copper to the continent of Europe, or to the United States of America, which was worthy of notice, before the year 1830; in fact, previous to that time, we imported considerable quantities of foreign copper for re-exportation to India. It is easy to explain how the produce of foreign ores, being prohibited from export in any other shape, has, in fact, opened for itself a new *debouché*, and this is illustrated by the table, showing the growth of the export of unwrought copper from 1830. To prove that this is not merely a simultaneous advance in the export of all sorts of copper, a corrected table is subjoined from the official returns, comprising the whole export, and divided so as to illustrate the operation of the copper produce of foreign ores upon our foreign copper trade.

Copper exported :—

Years ending	Wrought.	Unwrought.		Total.
	To all parts.	To India.	To all parts.	To all parts.
	Tons.	*Tons.*	*Tons.*	*Tons.*
5th January, 1825 - - -	—	—	960	
1826 - - -	—	—	1	
1827 - - -	—	—	130	
1828 - - -	—	—	1329	
1829 - - -	—	—	1079	
1830 - - -	5327	1801	2682	8,009
1831 - - -	6172	2317	3150	9,322
1832 - - -	5171	2423	3714	8,885
1833 - - -	5855	2312	4569	10,424
1834 - - -	5417	1769	4019	9,436
1835 - - -	4787	2104	5283	10,072
1836 - - -	5948	1993	5935	11,883
1837 - - -	6105	1588	3909	10,014*

Production of Copper in Great Britain :

Years.	Ores.	Metal.
	Tons.	*Tons.*
1771—1781	28,185	3380
1781—1791	32,854	4123
1791—1801	48,034	4083
1801—1811	67,533	6060
1811—1816	78,237	7181
1816	83,058	7045
1817	75,016	6608
1818	80,525	6714
1819	92,234	7214
1820	92,672	7364
1821	98,803	8163
1822	106,723	9331
1826	128,459	—
1827	—	12,381
1828	153,600	12,169
1829	—	11,994
1830	—	13,097
1831	—	14,480
1832	—	14,463†

* Supplement to the Mining Journal, Feb. 28, 1838.
† Taylor's Records of Mining, Part I., p. 171.

opper produced in the several districts of Great Britain and Ireland :—

es from—	1828.	1829.	1830.	1831.	1832.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
- - -	1966	9763	10,890	12,218	12,099
- - -	434	318	368	312	949
England -	71	36	10	31	42
:sea - -	738	901	815	809	852
Wales - -	259	172	237	123	237
- - -	706	790	768	972	974
- - -	—	4	9	15	12
'rom the ores d Kingdom - l from foreign	12,169	11,994	13,097	14,480	14,465
- - -	—	30	124	100	56
- - -	12,169	12,024	13,221	14,580	14,521

opper for Cornwall in 1837.—The total quantity of ore sold was 142,089
.), yielding an average produce of eight per cent.; the quantity of fine
,209 tons 1 cwt.; and the average price of the ore 5l. 15s. 6d.; the
the sales for the twelve months being 822,516l. The standard upon
ury was 127l. 16s.; this was the highest for the year. Upon the 22d of
ie lowest, being only 93l. 18s. It went up again to 120l. 10s. upon the
but declined with some slight fluctuation to 107l. 18s. upon the 28th
The largest quantity sold at any one ticketing was 4670 tons, upon the
l the smallest 1088, upon the 17th of August. The highest produce
re eighths per cent. upon the 13th of July; and the lowest, seven, upon
iary. The greatest weekly total was 25,887l., upon the 2d of Novem-
st 5694l., upon the 17th of August. The average sum per week was

iroduce of Copper Ores and fine Metal in Cornwall, from 1800 to 1830.

.	Metal.		Value of Ore.			Metal.	Average Standard.		
l Cwts.	Tons.	Cwt.	£	s.	d.	Per Cent. of Ore.	Price per Ton. £	s.	d.
31	5187	0	550,925	0	0	9¼	133	3	6
l1	5268	0	476,331	0	0	9¼	117	8	0
37	5228	15	445,094	0	0	9⅜	110	18	0
37	5374	18	507,840	11	0	8⅝	136	5	0
39	6863	10	730,845	6	0	8⅜	138	5	0
37	6795	13	495,303	10	0	10	100	7	0
l8	5682	19	570,035	8	0	8½	132	5	0
l7	6720	7	549,665	6	0	9⅝	111	0	0
22	6369	13	627,501	10	0	8¼	130	12	0
l4	6697	4	447,959	17	0	8⅜	98	13	0
l4	6849	7	686,005	4	0	7⅞	134	15	0
l3	7508	0	602,441	12	0	8¼	113	15	0
23	9140	8	663,085	13	0	8⅜	104	0	0
)0	7823	15	587,178	0	0	7⅞	110	0	0
)8	9026	12	788,971	15	0	7⅝	123	3	0
56	9921	1	756,174	16	0	7⅝	112	7	0
)2	9656	10	717,334	0	0	7¾	109	14	0
)6	11,224	19	887,900	0	0	7¾	114	4	0
l7	12,271	14	893,402	15	0	8½	106	11	0

* Mining Review, Feb. 28, 1838.

Produce of Copper Mines in Cornwall, (on the authority of John Taylor, Esq.,F.R.S.)

Years.	Ore.	Metal.	Value.			Produce.	Standard.
	Tons.	*Tons.*	£	*s.*	*d.*	*Per Cwt.*	
1831	144,402	12,044	806,090	15	6	8¼	100
1832	137,357	11,948	825,612	6	0	8¼	100
1833	138,300	11,191	858,708	10	0	8¼	111
1834	143,296	11,226	887,902	0	0	7¾	114
1835	150,617	12,270	893,402	14	0	8¼	106
1836	140,981	11,647	957,752	8	6	8¼	115
1837	140,753	10,832	908,613	15	0	7¼	120

An account of the quantities of Foreign wrought and unwrought Copper, and Copper Ore imported and exported, and of British wrought and unwrought Copper exported from the United Kingdom; together with the quantities and value of Copper Ore smelted in Cornwall and Swansea, and the quantity of Copper produced in those places; and in the county of Devon; together with the market prices of sheet and cake Copper, in the year ending 5th January, 1835.

	Quantity.	Value.
		£ s. d.
Foreign Copper imported :		
Unwrought in bricks or pigs, rose and cast copper, *Cwts.*	5,389	
Part wrought, viz., bars, rods, or ingots, hammered or raised - - - - - - -	1,968	
Wrought plates and coin - - - - -	2	
— old for re-manufacture - - - -	493	
Copper ore Foreign - - - - - -	278,900	
Manufactures of copper, entered by weight - -	650	
— entered at value - -	—	5,253 0 0
Foreign copper exported, viz :—		
Unwrought, in bricks and pigs, rose and cast copper - - - - - - - - - *Cwts.*	6,898	
Part wrought, viz., bars, rods, or ingots, hammered or raised - - - - - - -	2,013	
Old, fit only for re-manufacture - - - -	265	
Smelted in the United Kingdom from foreign ore -	55,456	
Manufactures of copper, entered by weight - -	650	
— entered at value - - .	—	112 0 0
BRITISH COPPER.		
Exported, unwrought, in bricks and pigs - - - *Cwts.*	63,252	
— wrought sheets, nails, &c. - - -	103,433	
— wire - - - - -	56	
— of other sorts - - - -	15,197	
Total of British copper exported - - - -	182,225	
Ores sold in Cornwall :—		
Quantity of ore - - - - - - - *Tons*	150,617	
Value of ditto - - - - - - -	—	893,403 0 0
Quantity of metal - - - - - - *Tons*	12,270	
Standard - - - - - - -	—	106 11 0
Produce per cent. - - - - - -	8¼	
Ores sold, &c. in Swansea :—		
Quantity of ore - - - - - - *Tons*	28,746	
Value of ditto - - - - - - -	—	223,958 0 0
Quantity of metal - - - - - - *Tons*	2,832	
Standard - - - - - - -	—	101 18 0
Produce per cent. - - - - - -	9¼	
Copper sold in Devonshire { ore } { metal } - - - *Tons*	{ 5,114 455	
Total quantity of copper raised in the United Kingdom, exclusive of Anglesea and Staffordshire, and deducting 1083 tons of metal, value 88,207*l.*, the produce of 4985 tons of foreign ore sold at Swansea, included above,	14,474	

. (*Couperose verte*, Fr.; *Eisenvitriol*, Germ.) Sulphate of iron.

orail, Fr.; *Koralle*, Germ.) is a calcareous substance, formed by a polypus, which constructs in concert immense ramified habitations, consist-ablage of small cells, each the abode of an animal. The coral is therefore , which resembles a tree stripped of its leaves. It has no roots, but a foot :mispherical scull-cap, which applies closely to every point of the surface stands, and is therefore difficult to detach. It merely serves as a basis or coral, but contributes in no manner to its growth, like the root of an ordi-detached pieces have been often found at the bottom of the sea in a state l reproduction. From the above base a stem usually single proceeds, which es an inch in diameter, and from it a small number of branches ramify in directions, which are studded over with cells, each containing an insect. ien they extend their arms, feelers, or *tentacula*, resemble flowers, whence, a the form of the coral, they were classed among vegetable productions. styled zoophites by the writers upon Natural History.

oral is found in the Mediterranean. It is fished for upon the coasts of constitutes a considerable branch of trade at Marseilles. The coral is at-submarine rocks, as a tree is by its roots, but the branches, instead of rds, shoot downwards towards the bottom of the sea; a conformation ·eaking them off and bringing them up. For this kind of fishing, eight excellent divers, equip a felucca or small boat, called commonly a coral-arry with them a large wooden cross, with strong, equal, and long arms, . stout bag-net. They attach a strong rope to the middle of the cross, ι horizontally into the sea, having loaded its centre with a weight sufficient ιe diver follows the cross, pushes one arm of it after another into the hol-:ks, so as to entangle the coral in the nets. Then his comrades in the boat ιss and its accompaniments.

ς is nearly as dangerous as pearl fishing, on account of the number of sharks t the seas where it is carried on. One would think the diving-bell in its ticable state might be employed with great advantage for both purposes. :tly of a fine red color, but occasionally it is flesh-colored, yellow, or white. ferred for making necklaces, crosses, and other female ornaments. It is ι precious stones. See LAPIDARY.

ςe, Fr.; *Kork*, Germ.) is the bark of the *quercus liber*, Linn., a species of h grows abundantly in the southern provinces of France, Italy, and Spain. ken off by making coronal incisions above and below the portions to be ical incisions are then made from one of these circles to another, whereby be easily detached. It is steeped in water to soften it, in order to be flat-ure under heavy stones, and next dried at a fire which blackens its surface. bound up in bales and sent into the market.

vo sorts of cork, the white and the black; the former grows in France and ρain. The cakes of the white are usually more beautiful, more smooth, ·om knots and cracks, of a finer grain, of a yellowish gray color on both more smoothly than the black. When this cork is burned in close vessels gment called *Spanish black*.

nce is employed to fabricate not only bottle corks, but small architectural : models, which are very convenient from their lightness and solidity.

tters divide the boards of cork first into narrow fillets, which they after le into short parallelopipeds, and then round these into the proper conical shape. The bench before which they work is a square table, where 4 :eated, one at every side, the table being furnished with a ledge to prevent . falling over. The cork-cutter's knife is a broad blade, very thin, and fine vhetted from time to time upon a fine-grained dry whetstone. The work-to draw his knife edge over the cork, for he would thus make misses, and self, but rather the cork over the knife edge. He should seize the knife and, rest the back of it upon the edge of the table, into one of the notches nt it from slipping, and merely turns its edge sometimes upright and some-ide. Then holding the squared piece of cork by its two ends, between his thumb, he presents it in the direction of its length to the edge; the cork is cut into a rounded form by being dexterously turned in the hand. He next ·o ends, when the cork is finished and thrown into the proper basket along-arwards sorted by women or boys.

rs a much thicker kind of cork boards have been imported from Catalonia, nger and better corks may be made. In the art of cork-cutting the French aglish, as any one may convince himself by comparing the corks of their ttles with those made in this country.

count of its buoyancy in water, is extensively employed for making floats

to fishermen's nets, and in the construction of life-boats. Its impermeability to water has led to its employment for inner soles to shoes.

When cork is rasped into powder, and subjected to chemical solvents, such as alcohol, &c., it leaves 70 per cent. of an insoluble substance, called *suberine.* When it is treated with nitric acid, it yields the following remarkable products: — White fibrous matter 0·18, resin 14·72, oxalic acid 16·00, suberic acid (peculiar acid of cork) 14·4 in 100 parts.

Machine cork-cutting. — A patent was obtained some years ago by Sarah Thomson for this purpose. The cutting of the cork into slips is effected by fixing it upon the sliding bed of an engine, and bringing it, by a progressive motion, under the action of a circular knife, by which it is cut into slips of equal widths. The nature or construction of a machine to be used for this purpose may be easily conceived, as it possesses no new mechanical feature, except in its application to cutting cork. The motion communicated to the knife by hand, steam, horse, or other power, moves at the same time the bed also, which carries the cork to be cut.

The second part of the invention, viz., that for separating the cork into square pieces, after it has been cut into slips as above, is effected by a moving bed as before, upon which the slips are to be placed and submitted to the action of a cutting lever, which may be regulated to chop the cork into pieces of any given length.

The third part of the invention, viz., that for rounding or finishing the corks, consists of an engine to which is attached a circular knife that turns vertically, and a carriage or frame upon its side that revolves upon an axle horizontally.

This carriage or frame contains several pairs of clamps, intended respectively to hold a piece of the square cut cork by pressing it at the ends, and carrying it lengthways perpendicularly; which clamps are contrived to have a spindle motion, by means of a pinion at the lower end of their axles, working into a spur-wheel.

The machinery, thus arranged, is put in motion by means of bands and drum-wheels, or any other contrivance which may be found most eligible; and at the same time that the circular knife revolves vertically, the frame containing the clamps with the pieces of cork, turns horizontally, bringing the corks, one by one, up to the edge of the knife, when, to render each piece of cork cylindrical, the clamps, as above described, revolve upon their axes, independently of their carriage, by which means the whole circumference of the cork is brought under the action of the knife, the superfluous parts are uniformly pared off, and the cork is finished smooth and cylindrical.

CORROSIVE SUBLIMATE; bichloride of mercury.

CORUNDUM·; or *Telesie;* a very hard genus of aluminous minerals, to which the gems, sapphire, ruby, salamstein, and adamantine spar belong.

COTTON DYEING. (*Teinture de Coton,* Fr.; *Baumwollenfärberei,* Germ.) Cotton and linen yarns and cloths have nearly the same affinity for dyes, and may therefore with propriety be treated, in this respect, together. After they have acquired the proper degree of whiteness (see BLEACHING), they are still unfit to receive and retain the dyes in a permanent manner. It is necessary, before dipping them into the dye-bath, to give them a tendency to condense the coloring particles within their cavities or pores, and to communicate such chemical properties as will fix these particles so that they will not separate, to whatever ordinary trial they may be subjected. All the colors which it would be desirable to transfer to these stuffs unfortunately do not possess this permanence. Men of science engaged in this important art have constantly aimed at the discovery of some new processes which may transfer into the class of fast colors those dyes which are at present more or less fugitive. Almost all the goods manufactured of cotton, flax, or hemp, are intended to be washed, and ought, therefore, to be so dyed as to resist the alkaline and soapy solutions commonly used in the laundry. Vitalis distinguished dyed cottons into three classes; 1. the *fugitive,* or fancy-colored (*petit teint*), which change their hue or are destroyed by one or two boils with soap; 2. those which resist five or six careful washings with soap, are *good dyes* (*bon teint*); and those which were still more durable, such as Turkey reds, may be called fast colors (*grand teint*). The colors of Brazil-wood, logwood, annotto, safflower, &c. are *fugitive;* those made with madder without an oily base, are *good;* and those of madder with an oily mordant, are *fast.* It is, however, possible to point out certain processes for giving these different orders of dyes a greater degree of fixity.

I shall describe, in the five following paragraphs, the operations conducive to the fixation of colors upon cotton and linen.

1. *Galling.* Either gall-nuts alone, or sumach alone, or these two substances united are employed to give to cotton the fast dye preparation. 2 or 3 ounces of galls for every pound of cotton, being coarsely pounded, are to be put into a copper containing about 80 gallons of water for every 100 pounds of cotton, and the bath is to be boiled till the bits of galls feel pasty between the fingers. The fire being withdrawn, when the bath becomes moderately cool, it is passed through a hair-cloth sieve. If during this operation the

liquor should become cold, it must be made once more as hot as the hand can bear. A portion of it is now transferred into another vessel, called a *back*, in which the cotton is worked till it be well penetrated with the decoction. It is then taken out, wrung at the peg or squeezed in a press, and straightway hung up in the drying-house. Some more of the fresh decoction being added to the partially exhausted liquor in the back, the pro cess is resumed upon fresh goods.

The manipulation is the same with sumach, but the bath is somewhat differently made; because the quantity of sumach must be double that of galls, and must be merely infused in very hot water, without boiling. When galls and sumach are both prescribed, their baths should be separately made and mixed together.

2. *Aluming.* Alum is a salt which serves to prepare cotton for receiving an indefinite variety of dyes. Its bath is made as follows : For 100 pounds of scoured cotton, about 30 gallons of water, being put into the copper, are heated to about 122° F., when 4 ounces of alum, coarsely pounded, are thrown in for every pound of cotton, and instantly dissolved. Whenever the heat of the bath has fallen to about 98° F., the cotton is well worked in it, in order that the solution may thoroughly penetrate all its pores. It is then taken out, wrung at the peg or squeezed in the press, and dried in the shade. The solution of alum is of such constant employment in this kind of dyeing, that it should be made in large quantities at a time, kept in the alum tun, where it can suffer no deterioration, and drawn off by a spigot or stop-cock as wanted.

There are certain colors which require alum to be deprived of a portion of its acid excess, as a supersalt; which may be done by putting 1 ounce of crystals of soda into the tun for every pound of alum. But so much soda should never be used as to cause any permanent precipitation of alumina. When thus prepared, it is called *saturated alum*, though it is by no means neutral to litmus paper; but it crystallizes differently from ordinary alum.

Cotton does not take up at the first aluming a sufficient quantity of alum; but it must receive a second, or even a third immersion. In every case the stuff should be thoroughly dried, with an interval of one or two days between each application; and it may even be left for 10 or 12 hours moist with the alum bath before being hung in the air. When the cotton is finally dry, it must be washed before being plunged into the dye bath; otherwise, the portion of alum not intimately combined with the cotton, but adhering externally to its filaments, would come off by the heat, mix with the bath, alter the color by dissolving in it, and throw it down to the bottom of the copper, in the form of a lake, to the great loss of the dyer. Madder reds, weld yellows, and some other colors are more brilliant and faster when acetate of alumina, prepared with acetate of lead, alum, and a little potash, is used, than even saturated alum. This mordant is employed cold, and at 4° Baumé.

3. *Mordants.* See this article in its alphabetical place.

4. *Dye baths* are distinguished into two classes; the coloring bath, and the dyeing bath. The former serves to extract the coloring matters of the different substances, with the exception of madder, which is always used in substance, and never as an extract, infusion, or decoction. In all these cases, when the color is extracted, that is, when the dye bath is completed by the degree of heat suited to each substance, it is then allowed to cool down a certain way, and the cotton is worked or winced through it, to get the wished-for tint. This is what is called the dye bath. Several coloring baths are made in the cold; and they serve to dye also in the cold; but the greater part require a heat of 90° or 100° to facilitate the penetration of the stuffs by the coloring particles. The description of the several dye baths is given under the individual dyes.

5. *Of the washing after the dyeing.*—The washing of the cottons after they have received the dyes, is one of the most important operations in the business. If it is not carefully performed, the excess of color not combined with the fibres is apt to stain whatever it touches. This inconvenience would be of little consequence, if the friction carried off the color equally from all the points; but it does not do so, and hence the surface appears mottled. A well-planned dye house should be an oblong gallery, with a stream of water flowing along in an open conduit in the middle line, a series of dash-wheels arranged against the wall, at one side, and of dyeing coppers, furnished with self-acting winces or reels against the other. In such a gallery, the washing may be done either by hand, by the rinsing machine, or by the dash-wheel, according to the quality of the dye, and the texture of the stuffs. And they may be stripped of the water either by the jack and pin, by the squeezing roller, or by the press. Wooden pins are placed in some dye houses on each side of the wash cistern or pool. They are somewhat conical, 1½ foot high, 3½ inches in diameter at the base, 1½ at the top, are fixed firmly upright, and at a level of about 3 feet above the bottom of the cistern, so as to be handy for the workmen. See BRAZIL-WOOD, FUSTIC, MADDER, BLACK DYE, BROWN DYE, &c., as also BLEACHING, MAN, CALICO PRINTING, DUNGING, DYEING, &c.

COTTON MANUFACTURE. (*Filature de Coton,* Fr.; *Baumwollenspinnerei,*

Germ.) Cotton is a filamentous down, which invests the seeds of the plant called *gossypium* by Linnæus, and placed by him in the class *monadelphia*, and order *monandria*, but belonging to the natural family of *malvaceæ*. It has a cup-shaped calyx, obtusely five-toothed, enclosed in a three-cleft exterior calyx; the leaflets are united at their base, of a heart shape, and toothed; stigmas three to five; capsule three to five celled and many seeded; seeds bearing a downy wool. Thirteen species are described by Decandolle, but their characters are very uncertain, and no botanist can assign to a definite species of the plant, the very dissimilar staples of the cotton filaments found in commerce. The leaves are generally palmate and hairy; and the blossoms are large, and of a beautiful yellow. The *gossypium religiosum* of Tranquebar has white blossoms in some of its varieties, to which probably the white cotton of Rome, cultivated in the Jardin des Plantes at Paris, belongs. The filaments differ in length, flexibility, tenacity, and thickness, in different cottons, whence the great differences of their value to the cotton-spinner, as the prices current in the market show. Thus, at Liverpool, on the 1st of December, 1835, the following values were assigned to the following cottons:—

					s.	d.	s.	d.
Sea-island	-	-	-	-	1	6 to	2	6
Demarara and Berbice	-	-	-	0	9	1	0
Pernambuco	-	-	-	-	0	10¾	1	1½
Egyptian	-	-	-	-	0	11½	1	2½
New Orleans	-	-	-	-	0	7¾	1	0
Bahia	-	-	-	-	0	8¼	0	10
Upland Georgia	-	-	-	-	0	7½	0	11½
West Indian	-	-	-	-	0	7¾	0	9
Surat	-	-	-	-	0	6¼	0	8
Madras	-	-	-	-	0	6¼	0	8
Bengal	-	-	-	-	0	5¼	0	6¼

But it is to be observed, that there are varieties of the Sea-island Georgian cotton, so highly prized by the spinner of fine yarn, as to fetch 3s., 4s., or even 5s. per pound.

The filaments of cotton, when examined with a good microscope, are seen to be more or less riband-like, and twisted; having a breadth varying from $\frac{1}{800}$ of an inch in the strongest Smyrna or candle-wick cotton of the Levant, to $\frac{1}{2500}$ of an inch in the finest Sea-island.

The main distinction between cottons in the pod, is that of the black-seeded and the green seeded; for the former part with their downy wool very readily to a pair of simple rollers, made to revolve nearly in contact, by the power of the human arm; while the latter retain the wool with much force, and require to be ginned, as the operation is called, by a powerful revolving circular saw-mechanism, usually driven by horse or water power. After the cotton wool is thus separated from the seeds, it is packed in large canvass bags, commonly with the aid of a screw or hydraulic press, into a very dense bale, for the convenience of transport. Each of the American bags contains about 340 lbs. of cotton wool. When this cotton is delivered to the manufacturer, it is so foul and flocky, that he must clean and disentangle it with the utmost care before he can subject it to the carding operation.

317
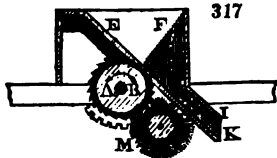
Fig. 317, A B, is a roller, about 9 inches in diameter, which revolves in the direction of the arrow. This cylinder consists of a parallel series of oblique pointed circular saws made fast to one axis, and parted from each other by wooden rings nearly one inch and a half in thickness. Above the cylinder, is a kind of hopper E F, into which the ginner throws the seed cotton, which falls upon a grating, up through which small segments of the saw-teeth project, so as to lay hold of the fibres in their revolution, and pull them through, while the seeds, being thus separated, roll down the slope of the grid, to be discharged from the spout I K. M is a cylindrical brush placed below the grating, which revolves against the saw-teeth, so as to clear them of the adhering cotton filaments.

The *willow*, which was originally a cylindrical willow basket, whence its name, but is now a box made of wood, with revolving iron spikes, is the first apparatus to which cotton wool is exposed, after it has been opened up, picked, and sorted by hand or a rake, in what is called a *bing*. The willow exercises a winnowing action, loosens the large flocks, and shakes out much of the dirt contained in them. The frame of the willow is about 2 feet wide, and turns with its spikes at the rapid rate of 600 revolutions per minute, whereby it tosses the cotton about with great violence. The heavy impurities fall down through the grid bottom. It is exposed, however, for only a few minutes to the action of this machine. For factories, which work up chiefly the coarser and fouler cottons of India, and Upland Georgia, the conical self-acting willow, as

:ted by Mr. Lillie at Manchester, is much employed. In it, the cotton is put in at
:ow end of the truncated cone, which, being spiked, and revolving rapidly within
' concentric case upon a horizontal axis, wafts it on towards the wide end, while
irities are partly shaken out through the grid or perforated bottom, and partly
up through revolving squirrel wire cages, by the centrifugal action of a fan. This
rerful automatic engine, deserving the study of the curious, and is as safe as it is
il. The cone of this huge machine makes from 400 to 600 turns per minute, and
in 7200 pounds, or 24 bags, in a day.

shaking out the grosser impurities by the willow, the cotton spinner proceeds
rate each individual filament of cotton wool from its fellow, so as to prepare it
ling, and to free it from every particle of foreign matter, whether lighter or
than itself. This second operation is performed by what are called batting
), scutching, and blowing machines, which are all now much the same, what-
ference of signification the name may have. Indeed, each machine not only
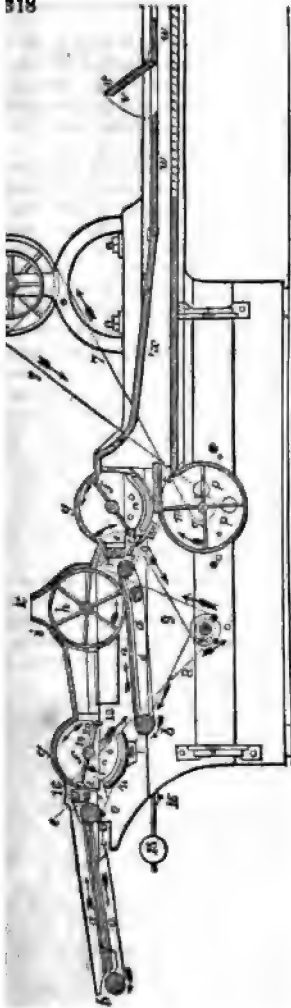
beats, scutches, but blows. *Fig.* 318 ex-
hibits a longitudinal section of a good
blowing engine of modern construction.
The machine is about 18 or 19 feet long,
and three feet across within the case. The
whole frame is made of cast-iron, lined
with boards, forming a close box, which has
merely openings for introducing the raw
cotton wool, for taking out the cleansed
wool, and removing the dust as it collects
at the bottom. These doors are shut du-
ring the operation of the machine, but may
be opened at pleasure, to allow the interior
to be inspected and repaired.

The introduction of the cotton is effected
by means of an endless cloth or double
apron, which moves in the direction of
the arrow *a a*, at the left end of the figure,
by passing round the continually revolving
rollers at *b* and *c*. The two rollers at *e*,
being the ones which immediately intro-
duce the cotton into the jaws, as it were,
of the machine, are called the feed rollers.
The batting arm, or revolving diameter,
f e, turns in the direction of the arrow, and
strikes the flocks violently as they enter, so
as to throw down any heavy particles upon
the iron grating or grid at *n*, while the
light cotton filaments are wafted onwards
with the wind, from the rotation of the
scutcher in the direction of arrow *a'*, along
the second travelling apron, upon which the
squirrel cage cylinder presses, and applies
the cotton in the form of a lap. Above the
cylindric cage *h*, which turns in the di-
rection of its arrow, there is a pipe *k*, the
continuation of the case *i*. This pipe,
though broken off in the figure, com-
municates by a branch pipe with an air-
sucking fan ventilator, not seen in this
figure, but explained under FOUNDRY. The
cage *h*, by its rotation, presses down, as we
have said, the half-cleaned cotton upon the
cloth *a'*, which carries it forward to the
second scutcher *f'*, by the second set of
feed rollers *e'*. The second scutcher throws
down the heavy dust upon the second
grid *n'*, through which it falls upon the
bottom of the case. The first scutcher
makes about 1280 strokes of each of its
two arms in a minute; the second 1360.

id rollers for each are fluted. The feed cloth is either sustained by a board, or
of parallel spars of wood, to secure it against bagging, which would render the

delivery of the cotton irregular. The feed rollers make 8 turns in the minute; and as their diameter is $1\frac{1}{2}$ inches, they will introduce 8 times their circumference, or 37·7 inches of the cotton spread upon the apron in that time. Upon every 12th part of an inch of the cotton, therefore, nearly 3 blows of the scutcher arm will be applied. The second feed rollers move relatively with more slowness, so that for every 2·4 blows of the scutcher, only one twelfth of an inch of cotton wool is presented.

The fan is enclosed in a cylindrical case. The wings or vanes revolve from 120 to 150 times in the minute; and while they throw the air out with nearly this velocity at their eccentric outlet in the circumference, they cause it to enter, with equal velocity, at the centre. With this centre the squirrel cage is connected by a pipe, as above stated. The sound filaments of the cotton are arrested by the sieve surface of the cylindric cage, and nothing but the broken fragments and the light dust can pass through.

The cotton wool in the blowing machine is wafted by the second scutcher into the space x, w, x, provided with a fine grid bottom; or it is sometimes wound up there by rollers into a lap.

In *fig.* 318 an additional ventilator is introduced beneath at n, o, o, to aid the action of the scutchers in blowing the cotton onwards into the oblong trough a. The outlet of that fan is at t; and it draws in the air at its axis q. u and v are two doors or lids for removing the cleaned cotton wool. This last fan is suppressed in many blowing machines, as the scutching arms supply a sufficient stream of air. The dotted lines show how the motion is transmitted from the first mover at s, to the various parts of the machine. 6′ 6′ represent the bands leading to the main shafting of the mill. A machine of this kind can clean fully 600 pounds of short-stapled cotton wool in a day, with the superintendence of one operative, usually a young woman, to distribute the cotton upon the first feed cloth.

The second Blowing machine is usually called a *lap* machine, because, after blowing and scutching the cotton, as above described, it eventually coils the fleece upon a wooden roller at the delivering end of the apparatus. It is sometimes, also, called a *spreading machine*. A section of it is shown in *fig.* 319. The breadth of this machine is about 3 feet, as the lap formed is prepared for the usual breadth of the breaker cards, namely, 3 feet. Where the cards are only 18 inches broad, the lap machine is also made of the same breadth. In the figure we see the feed-cloth, the scutching barrel, the squirrel suction, and spreading cage, and the rollers for coiling up the lap. The lever shown below is for removing the pressure weight from the axis of the lap
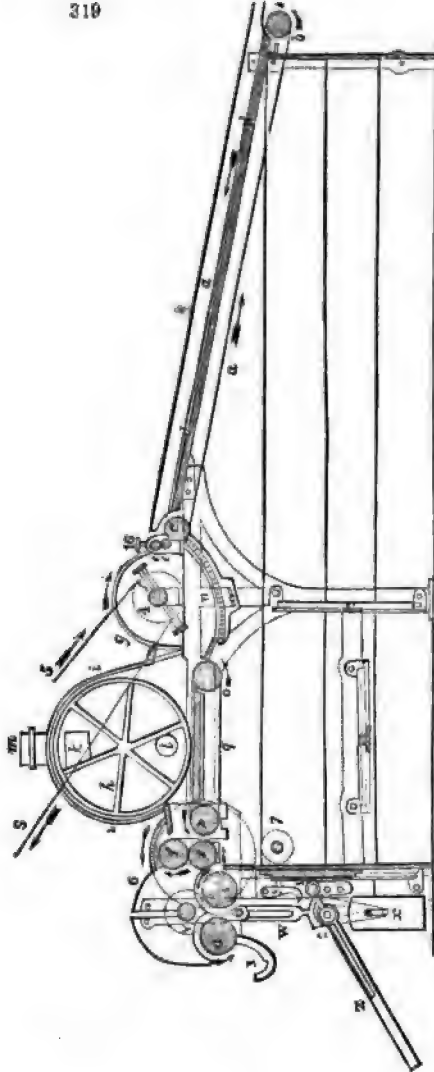
a, when a full one is to be removed, and replaced by an empty one. m, at the top, e commencement of the pipe which leads to the suction fan, or ventilator. The ness of the lap in this machine must be nicely regulated, as it determines, in a measure, the grist of the card-ends, and even the rovings. In 12 hours such a lap ine will prepare 650 pounds of cotton.

g. 320 is the first scutching machine, now never seen except in the oldest factories. s the feed cloth; G H and M N are the two scutcher frames.
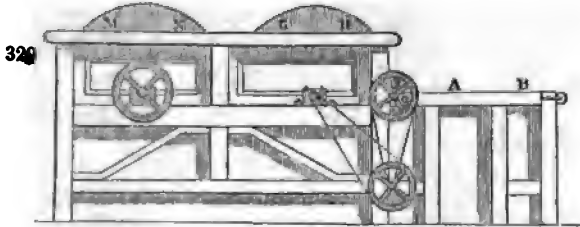
rding is the next operation in a cotton factory. Cards are destined to disentangle idividual filaments from each other, and to lay them lengthwise, instead of being ed up and convoluted, as they usually are in leaving the blowing and lap ines. Carding consists in the mutual action of two opposite surfaces, which are ed thick with oblique angled hooks. The wires of which these hooks are made must ry hard drawn in order to render them stiff and elastic. The middle part of the s shows one of the staples or double teeth, the structure of which has been partly
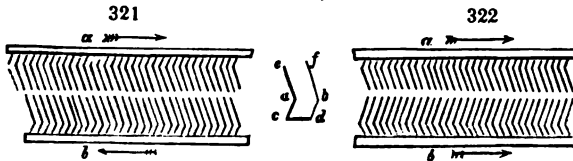
ined under CARD. Suppose a, fig. 321, to be a piece of a card fillet, and b to be er piece, each being made fast with pins to a board; the teeth of these two cards t in opposite directions, but are very near together, and parallel. Now suppose k or tuft of cotton placed between two such bristling surfaces. Let a be moved direction of its arrow, and let b be moved in the opposite direction, or even let it in at rest. Every filament of the cotton will be laid hold of by each set of teeth, their surfaces are thus drawn over each other; the teeth of a will pull them in a ird direction, while those of b will tend to retain them, or to pull them backwards. loops or doublings will, by both movements, be opened or drawn out, so that the s will be converted into rows of parallel filaments, lying alongside or before each . Each tooth will secure to itself one or more of them, and by the friction of its , as well as the hooks of its points, will draw them to their utmost elongation. igh one stroke of the opposite cards be inadequate to produce this equable arrange-, yet many repeated strokes must infallibly accomplish the end in view, of laying ibres parallel.

t us suppose this end effected, and that all the fibres have been transferred to the a, a transverse stroke of b will draw over to it a certain number of them, and in-at each stroke there will be a new partition between the two cards, with increased llelism, but still each card will retain a great deal of the cotton. To make one strip another, the teeth of one of them must be placed in a reverse position, as m in fig. 322.

a be now drawn in the direction of its arrow along the face of b, it will inevitably out all, or almost all, the filaments from it, since the hooks of b have, in this po-t, no power of retaining them. Even the doubled fibres or loops will slip over the ng point of b, in obedience to the traction of a. By considering these two relative tions of the cards, which take place in hand cards, simply by reversing one of them person will be able to understand the play of a cylinder card against its flat top, or st another cylinder card, the respective teeth being in what we may call the teasing tion of fig. 321; and also the play of a cylinder card against the doffer cylinder, hat may be called the stripping position of fig. 322.

ylinder cards, so essential to the continuity and despatch of cotton factory labor, e the ingenious invention of Lewis Paul of Northampton, but were greatly improved brought into nearly their present operative state by Sir Richard Arkwright. A

carding engine consists of one or more cylinders, covered with card-leather (sometimes called card cloth), and a set of plane surfaces similarly covered, made to work against each other, but so that their points do not come into absolute contact. Some cards consist entirely of cylinders, the central main cylinder being surrounded by a series of smaller ones called urchins or squirrels. These are used solely for preparing the coarser stapled cotton, and sheep's wool for the wool spinner.

Fig. 323 represents a card of excellent construction, which may be called a *breaker* and *finisher*, as it is capable of working up the fleece roll of the lapping machine directly into a card-end or riband fit for the drawing machine. In fine spinning mills there are always, however, two cards; one coarser, called a breaker, which turns off

323
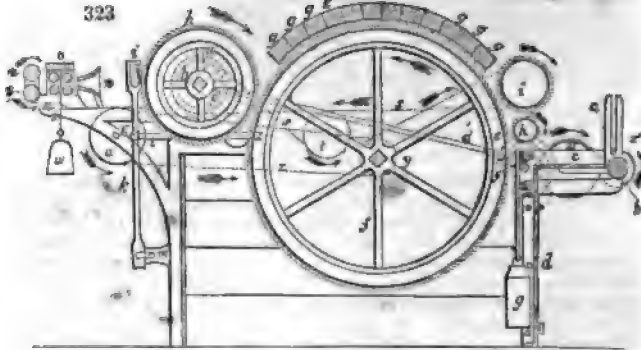
the cotton in a broad fleece of extreme thinness, which is lapped round a cylinder; and constitutes the material presented to the finisher card, which has teeth of a finer construction.

a is one of the two upright slots, which are fixed at each side of the engine for receiving the iron gudgeons of the wooden cylinders round which the fleece of the lapping machine is rolled. The circumference of this coil rests upon a roller *b*, which is made to turn slowly in such a direction as to aid the unfolding of the lap by the fluted cylinders *e*. The lap proceeds along the table seen beneath the letter *c*, in its progress to the fluted rollers, which are an inch and one sixth in diameter, and have 28 flutings in their circumference. *g* is a weight which hangs upon the axis of the upper roller, and causes it to press upon the under one : *f* is the main card drum ; *g g g*, the arch formed by the flat top cards ; *h*, the small card cylinder for stripping off the cotton, and therefore called the doffer, as we have said ; *i*, the doffer-knife or comb for stripping the fleecy web from the doffer ; *k l q m*, the lever mechanism for moving these parts. At *d* there is a door for permitting the tenter to have access to the interior of the engine, and to remove whatever dirt, &c. may happen to fall into it. In *fig.* 324 we see the manner of fixing the flat tops *g g* over the drum ; and for making the matter clearer, three of the tops are removed. Upon the arched cast-iron side of the frame, a row of strong iron pins *k* are made fast in the middle line ; and each top piece has, at each of its ends, a hole, which fits down upon two such opposite pins. *l l* are screws whose heads serve as supports to the tops, by coming into contact with the bottom of the holes, which are not of course bored through the wood of the tops. By turning the heads of these screws a little the one way or the other, the pins may be lengthened or shortened in any degree, so as to set the tops very truly in adjustment with the drum teeth revolving beneath them. *h'* is the small runner or urchin, and *i'* the large runner ; both of which are spirally covered from end to end with narrow card fillets in the same manner as the doffer. The main drum is on the contrary covered with card cloth, in strips laid on parallel to its axis, with interjacent parallel smooth leather borders. The teeth of these several cards are set as represented in the figure, and their cylinders revolve as the arrows indicate. The runners as well as the doffer cylinder may be set nearer to or farther from the drum *f* ; but the screws intended for this adjustment are omitted in the drawings, to avoid confusion of the lines.

The card-end or fleece taken off the doffer *h* by the crank and comb mechanism *i k m*, passes through the tin plate or brass funnel *n, fig.* 323, whereby it is hemmed in and contracted into a riband, which is then passed through between a pair of drawing rollers *o*. It is next received by the rollers *u v*, which carry it off with equable velocity, and let it fall into the tin cans placed below, or conduct it over a friction pulley, to be wound along with many other card-ends upon a lap roller or large bobbin. The latter mechanism is not shown in this figure. A sloping curved tin or brass plate, channelled or

ridged along its surface, conducts the card ribands separately; there are two smooth iron rollers for condensing the several ribands, and a wooden pin round which the ribands are lapped, resting between two leather-covered rollers, one of which receives motion
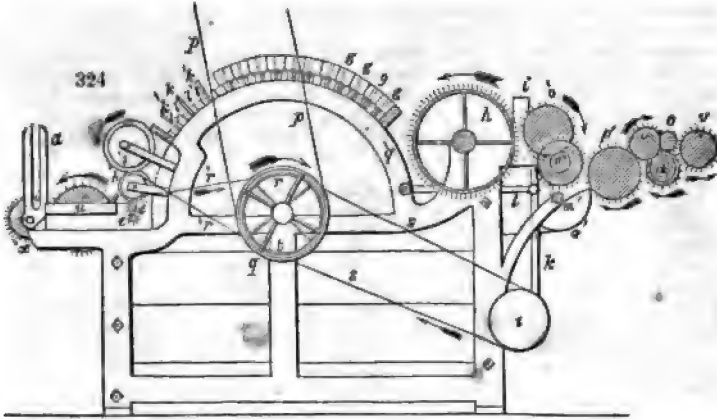
from mill gearing, and imparts it by friction to the lap roller over it. The iron ends of the lap roller lie in upright slots, which allow them freedom to rise as the roller gets filled with fleece.

The two pairs of rollers at *o* effect the extension of the card-end, and reduce its size. The under rollers are made of iron and fluted; the upper ones are also made of iron, but they are covered with a coat of leather, nicely glued on over a coat of flannel, which two coats render them both smooth and elastic. Two weights, *w*, press the upper cylinders steadily down upon the under ones. Between the first and second pair there is a certain interval, which should be proportioned to the length of the cotton staple. The second, or that furthest from the funnel, revolves with greater velocity than the first, and therefore turns out a greater length of riband than it receives from its fellow; the consequence is a corresponding extension of the riband in the interval between the two pairs of rollers.

The motions of the several parts of the engine are effected in the following way. The band, *p p, fig.* 324, which comes down from the pulley upon the main shaft near the ceiling of the work-room, drives, by means of the pulley *q*, the drum *f, fig.* 323, with a velocity of from 120 to 140 revolutions in a minute. From another pulley *r*, on the axis of the drum, the axis of *t* is driven by the band *s* working round the pulley *t* on its end. This shaft drives the crank and lever mechanism of the stripper knife *i*. A third pulley of the same size as *r* is fixed just within the frame to the other end of the drum, and from it a crossed or close band *r'* goes to a pulley upon the small runner *h'*, to give this its rapid rotation. Upon the opposite end of the engine in *fig.* 323, these wheels and pulleys are marked with dotted lines. Here we may observe, first, a pulley *y* upon the drum, and a pulley *a'*, which receives motion from it by means of the band *z*. The axis of *a'* carries in front a pinion *m'*, which sets in motion the wheel *n'*. The latter imparts motion, by means of a pinion and intermediate wheel *o'*, to the wheel *h* on the doffer cylinder, and consequently to that cylinder on the one hand; and it turns, by the carrier wheel *p'*, a wheel *x*, whose axis is marked also with *x* in *fig.* 323, upon the other hand. The axis of *x', fig.* 323, carries, towards the middle of the engine, a very broad wheel, which is represented by a small dotted circle. The toothed wheel *v* of the smooth roller *v', fig.* 323, and the two toothed wheels *o o, fig.* 324, of the under rollers *o o, fig.* 323, work into that broad wheel. The wheel of the second or delivery fluted roller is seen to be smaller than that of the first, by which means the difference of their velocities is obtained. The large runner *i* is driven from the main drum pulley, by means of the band *s'*, and the pulley *u', fig.* 323. The said band is crossed twice, and is kept in tension by the pulley *t'*, round which it passes. The motion of the fluted rollers *e*, which feed in the cotton fleece, is effected by means of a bevel wheel *b'* on the end of the doffer, which works into a similar wheel *c'* on the oblique axis *d'* (dotted lines across the drum), of the pinion *e'* upon the lower end of the same axis which turns the wheel *f'*, upon the under feed roller.

Each of the feed rollers, *fig.* 324, bears a pinion *e e* at one end, so that the upper roller turns round with the under one. The roller *b, fig.* 323, is set in motion by means of

its wheel x'; which is driven by a wheel v' on the other end of the under feed roller, through the intervention of the large carrier wheel w'. The original or first motion of b must be as quick as that of the fluted feed rollers e, in order that the former may uncoil as much lap as the latter can pass on.

The annexed table exhibits the proper velocities of the different cylinders and rollers of the carding engine, which, however, are not invariable, but may be modified according to circumstances, by changing the pinions e', *fig.* 323, and w', according to the quality or length of the cotton staple. The velocities stated in the table will be obtained when the pulley a', *fig.* 323, is made greater than y in the proportion of 3 to 2, and the wheels and pinions have the following number of teeth : m', 18; v', 50; its pinion, 18; h, 128; x, 24; the broad wheel upon the shaft of x, 37 teeth; the wheel o of the first fluted roller, 35; that of the second, 21; v, 44; b' and e', 54; e', 10; f, 63. .

Names of the parts.	Diameter in inches.	Circumference in inches.	Revolutions in one minute.	Velocity.
Drum f - - • - -	35	109·9	130	142·87
Doffer h - - - - -	14	43·96	4·38	192·5
Runner or urchin i' - - - -	6·25	19·62	5·	98·1
Ditto h' - - - - -	3·5	11·	470·	5170·
Fluted feed roller e • - • -	1·167	·664	0·696	2·55
First drawing roller o - - -	1·	·14	68·71	215·75
Second ditto - - - -	1·167	3·664	114·52	419·6
Smooth delivery roller v - -	2·5	7·85	54·66	429·08

The operation of the runners, h' and i', becomes very plain on comparing their speed with one another and with that of the main-drum, and taking into account the direction of the card teeth. The cotton wool, taken off from the feed-rollers by the drum, is caught by the opposite teeth of the large runner i', which, on account of its slower surface rotation (98 inches per minute), may be considered to be at rest with reference to the drum, and therefore, by holding the cotton in its teeth, will commence its carding. The small runner h', in consequence of its greater surface velocity (5170 inches per minute), will comb the cotton-wool back out of the teeth of the large runner, but it will give it up in its turn to the swifter teeth of the drum, which, in carrying it forwards, encounters the teeth of the top cards, and delivers up the filaments to their keeping for some time. We thus see how essential the runners are to the perfection as well as to the acceleration of the carding process for ordinary cotton wool, though for the slenderer and longer filaments of the sea-island kind they are not so well adapted. In cleaning the carding-engines the little runner must be looked to every time that the drum is examined. The large runner and the doffer require to be cleaned together. The quantity of cotton spread upon the feed-cloth, the velocity of it, and of the drawing-rollers, must all be carefully adjusted to the grist of the yarn intended to be spun.

Suppose the sizes and velocities to be as represented in the preceding table, that the engine is a double card 36 inches broad, and that it is furnished with a lap from the lap-machine of which 30 feet in length weigh 5 lbs. In one minute the surface of the feed-rollers, e, passes 2·55 inches of that lap onwards; in the same time the main-drum will work it off. To card the whole 30 feet, therefore, 141 minutes, or 2 hours and 21 minutes will be required. In this time the circumference of the rollers, u r, moves through a space of $1·41 \times 42,908$ in. $= 5042$ ft., and delivers a card-end of that length, weighing 5 lbs., *minus* 6 per cent. for waste, that is, 4 lbs. $1\frac{1}{2}$ oz. One pound will form a riband 1072 feet long, being, according to the English mode of counting, about number $\frac{1}{3}$, or 0·357. The extension of the cotton-fleece to this degree proceeds as follows :—In the 141 minutes which the feed-rollers take to introduce the 30 feet of lap, the doffer, h, makes 617·58 revolutions, and the comb, or doffer knife, i, detaches from the doffer teeth a thin fleecy web of 2262 feet in length. The first drawing pair of fluted rollers,
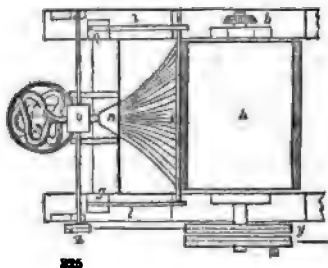
by its quick motion, with the aid of the funnel, m, converts this fleece into a riband 2535 feet long. The second pair of the fluted rollers extends this riband to 4390 feet, since their surface velocity is greater than the first pair in that proportion. The slight elongation (of only 112 feet, or about $\frac{1}{44}$) which takes place between the delivery fluted rollers and the smooth cylinders, v, u, serves merely to keep the card-end steadily upon the stretch without folding. *Fig.* 325 is a plan of the card and the fleece, where k is the cylinder, n is the funnel, u the pressing rollers, and h' the card-ends in the can.

Figs. 326, 327, represent skeletons of the old cards to facilitate the comprehension of these complex machines. *Fig.* 326 is a plan; F is the main drum; M M is the doffer
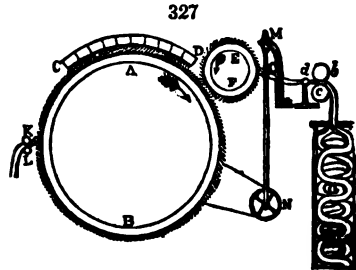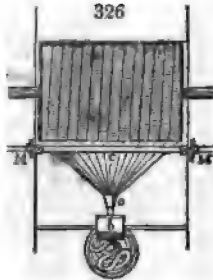
knife or comb; G the carded fleece hemmed in by the funnel *a*, pressed between the rollers *b*, and then falling in narrow fillets into its can. *Fig.* 327, K L are the feed rollers; A B the card drum; C D the tops; E F the doffer card; M N the doffer knife; *d, b, c*, the card-end passing between compressing rollers into the can *a*.

The drawing and doubling are the next operation. The ends, as they come from the cards, are exceedingly tender and loose, but the filaments of the cotton are not as yet laid so parallel with each other as they need to be for machine spinning. Before any degree of torsion therefore be communicated, a previous process is required to give the filaments a level arrangement in the ribands. The drawing out and doubling accomplish this purpose, and in a manner equally simple and certain. The means employed are drawing-rollers, whose construction must here be fully explained, as it is employed in all the following machines; one example of their use occurred, indeed, in treating of the cards.
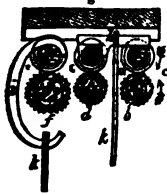
Let *a* and *b*, *fig.* 328, represent the section of two rollers lying over each other, which touch with a regulated pressure, and turn in contact upon their axes, in the direction shown by the arrows. These rollers will lay hold of the fleecy riband presented to them at *a*, draw it through between them, and deliver it quite unchanged. The length of the piece passed through in a given time will be equal to the space which a point upon the circumference of the roller would have percured in the same time; that is, equal to the periphery of one of the rollers multiplied by the number of its entire revolutions. The same thing holds with regard to the transmission of the riband through between a second pair of rollers, *c, d*, and a third, *e, f.* Thus the said riband issues from the third pair exactly the same as it entered at *a*, provided the surface speed of all the rollers be the same. But if the surface speed of *c* and *d* be greater than that of *a* and *b*, then the first-named pair will deliver a greater length of riband than the last receives and transmits to it. The consequence can be nothing else in these circumstances than a regulated drawing or elongation of the riband in the interval betwixt *a, b*, and *c, d*, and a condensation of the filaments as they glide over each other, to assume a straight parallel direction. In like manner the drawing may be repeated by giving the rollers, *e, f*, a greater surface speed than that of the rollers, *c* and *d*. This increase of velocity may be produced, either by enlarging the diameter, or by increasing the number of turns in the same time, or finally by both methods conjoined. In general the drawing-machine is so adjusted, that the chief elongation takes place between the second and third pair of rollers, while that between the first and second is but slight and preparatory. It is obvious, besides, that the speed of the middle pair of rollers can have no influence upon the amount of the extension, provided the speed of the first and third pair remains unchanged. The rollers, *a, b*, and *c, d*, maintain towards each other continually the same position, but they may be removed with their frame-work, more or less, from the third pair, *e, f*, according as the length of the cotton staple may require. The distance of the middle point from *b* and *d*, or its line of contact with the upper roller, is, once for all, so calculated, that it shall exceed the length of the cotton filaments, and thereby that these filaments are never in danger of being torn asunder by the second pair pulling them while the first holds them fast. Between *d* and *f*, where the greatest extension takes place, the distance must be as small as it can be without risk of tearing them in that way; for thus will the uniformity of the drawing be promoted. If the distance between *d* and *f* be very great, a riband passing through will become thinner, or perhaps break in the middle; whence we see that the drawing is more equable, the shorter is the portion submitted to extension at a time, and the nearer the rollers are to each other, supposing them always distant enough not to tear the staple.

The under rollers, *b d f*, are made of iron, and, to enable them to lay firmer hold of the filaments, their surfaces are fluted with triangular channels parallel to their axes. The upper rollers, *a c e*, are also made of iron, but they are smooth, and covered with a double coating, which gives them a certain degree of softness and elasticity. A coat of flannel is first applied by sewing or glueing the ends, and then a coat of leather in the same way. The junction edges of the leather are cut slanting, so that when joined by the glue (made of isinglass dissolved in ale) the surface of the roller may be smoothly cylindrical. The top rollers are sometimes called the *pressers*, because they press by means of weights upon the under ones. These weights are suspended to the slight rods *k k′* ; of which the former operates on the roller *e* alone, the latter on the two rollers *a* and *e* together. For this purpose the former is hung to a c shaped curve *i*, whose upper hook embraces the roller *e* ; the latter to a brass saddle *h*, which rests upon *a* and *c*. A bar of hard wood, *g*, whose under surface is covered with flannel, rests, with merely its own weight, upon the top rollers, and strips off all the loose hanging filaments. Similar bars with the same view are made to bear up under the fluted rollers *b d f*, and press against them by a weight acting through a cord passing over a pulley. Instead of the upper dust-covers, light wooden rollers covered with flannel are occasionally applied.

Were the drawing of a riband continued till all its fibres acquired the desired degree of parallelism, it would be apt, from excessive attenuation, to tear across, and thereby to defeat the purpose of the spinner. This dilemma is got rid of in a very simple way, namely, by laying several ribands together at every repetition of the process, and incorporating them by the pressure of the rollers. This practice is called *doubling*. It is an exact imitation of what takes place when we draw a tuft of cotton wool between our fingers and thumb in order to ascertain the length of the staple, and replace the drawn filaments over each other, and thus draw them forth again and again, till they are all parallel and of nearly equal length. The doubling has another advantage, that of causing the inequalities of thickness in the ribands to disappear, by applying their thicker to their thinner portions, and thereby producing uniformity of substance.
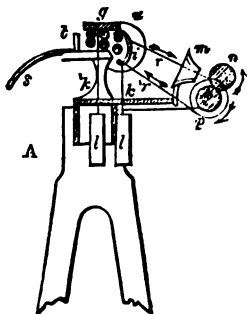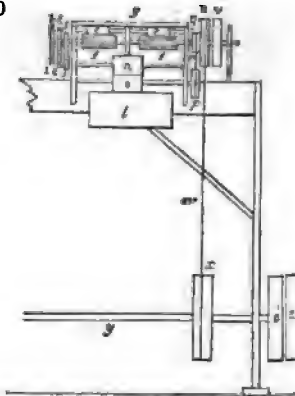
The drawing frame, as shown in section in *figs.* 328, 330, and in a back view in *fig.* 329, will require, after the above details, little further explanation. *l l* are the weights which press down the top rollers upon the under ones, by means of the rods *k k′* and hook *i*. Each fluted roller is, as shown at *f*, *fig.* 329, provided in the middle of its length with a thinner smooth part called the *neck*, whereby it is really divided into two fluted portions, represented by *c e* in the figure. Upon this middle neck in the pressure rollers, the hook *i* and the saddle *h* immediately bear, as shown in the former *fig.* 328. The card-ends, to the number probably of six, are introduced to the drawing frame either from tin cans, placed at *e e*, *fig.* 330, and at *A*, *fig.* 329, or from lap-bobbins; and, after passing through it, the ribands or slivers are received either into similar tin cans, as *g*, or upon other lap-bobbins upon the other side. These appendages may be readily conceived, and are therefore not exhibited in all the drawings. Three of the slivers being laid together are again introduced to the one fluted portion *a b*, *fig.* 328, and three other slivers to the other portion. The sloping curved tin or brass plate *s*, *fig.* 329, with its guide pins *t*, serves to conduct the slivers to the rollers. When the two threefold slivers have passed through between the three pairs of rollers, and been thereby properly drawn, they run towards each other in an oblique direction, behind the last roller pair *e f*, *fig.* 328, and unite, on issuing through the

conical funnel *m, fig.* 329, into a single riband or spongy sliver; which is immediately carried off with equable velocity by two smooth cast-iron rollers, *n o, figs.* 329 and 330, and either dropped into a can, or wound upon a large bobbin. The surface speed of these rollers is made a trifle greater than that of the delivery drawing rollers, in order to keep the portion of sliver between them always in an extended state. Four fluted drawing portions are usually mounted in one drawing frame, which are set a-going or at rest together. To save all unnecessary carrying of the cans from the back to the front of the frame, the drawing heads are so placed, that the first and third discharge their slivers at the one side, and the second and fourth at the other. By this arrangement, the cans filled behind one head, are directly pushed aside in front of the next drawing head; by which alternate distribution the work goes on without interruption.

The *fast* pulley *u, fig.* 330, by which the whole machine is driven, derives its motion from the main shaft of the mill by means of the band *w*. The similar pulley *z*, which sits loose upon the axis, and turns independently of it, is called the loose pulley; both together being technically styled *riggers*. When the operative desires to stop the machine, he transfers the band from the fast to the loose pulley by means of a lever, bearing a fork at its end, which embraces the band. Upon *y*, four pulleys such as *x* are fixed, each of which sets in motion a drawing head, by means of a band like *w* going round the pulleys *x* and *u*. On account of the inverted position of the heads, which requires the motion of *u* to be inverted, the bands of the first and third heads are open, but those of the second and fourth are crossed. Every head is provided with a loose pulley *v*, as well as the fast pulley *u*, in order to make the one stop or move without affecting the others. The shaft of the pulley *u* is the prolonged shaft of the backmost fluted roller *f*. It carries besides a small pulley *q*, which, by means of the band *r*, and the pulley *p, fig.* 329, sets in motion the undermost condensing roller *o*. The upper roller *n* presses with its whole weight upon it, and therefore turns by friction. The toothed wheel-work, by which the motions are communicated from the backmost fluted roller to the middle and front ones, is seen in *fig.* 330.

The wheel *f, fig.* 328, of 20 teeth, works in a 44-toothed carrier-wheel, on whose axis there are two smaller wheels; 2 with 26 teeth, and 1 with 22 teeth. The wheel *d, fig.* 330 of the middle roller, and the wheel *b* of the front roller, are set in motion by other carrier wheels; the first has 27 teeth, and the last 40. For every revolution of *b*, the roller *d* makes nearly 1¾ turns, and the roller *f* 4 revolutions. The top rollers revolve, as we have stated, simply by the friction of contact with the lower ones. Now suppose the diameter of the rollers *b* and *d* to be 1 inch or 12 lines, that of *f* 1¼ inches or 15 lines, the surface velocities of the three pairs of rollers in the series will be as 1, 1¾, and 5. Every inch of the cotton sliver will be therefore extended between the first and second pairs of rollers into 1¾ inches, and between the second and third or delivery pair into 5 inches; and after the sliver has passed through all the four drawing heads, its length will be increased 625 times = 5 × 5 × 5 × 5.

The further the drawing process is pushed, the more perfectly will its object be accomplished, namely, the parallelism of the filaments. The fineness of the appearance of the sliver after the last draught depends upon the number of doublings conjointly with the original fineness and number of drawings. The degree of extension may be increased or diminished, by changing the wheels in *fig.* 330, for others with a different number of teeth. Thus the grist or fineness of the sliver may be modified in any desired degree; for, when the subsequent processes of the mill remain the same, the finer the drawings the finer will be the yarn. For spinning coarse numbers or low counts, for example, six card-ends are usually transmitted through the first drawing head, and converted into one riband. Six such ribands again form one in the second draught; six of these again go together into the third sliver; and this sliver passes five-fold through the last draught. By this combination 1080 of the original card-ends are united in the finished drawn sliver = 6 × 6 × 6 × 5. The fineness of the sliver is, however, in consequence of these doublings, not increased, but rather diminished. For, by the drawing, the card-end has been made 625 times longer, and so much smaller; by the doubling alone it would have become 1080 times thicker; therefore, the original grist is to the present as 1 to the fraction $\frac{625}{1080}$; that is, supposing 1072 feet of the riband delivered by the card to weigh one pound, 625 feet, the sliver of the last drawing, will also weigh a pound, which corresponds in fineness to number 0·24, or nearly ¼.

The rearmost or last drawing roller has a circumference of nearly 4 inches, and makes about 150 revolutions per minute; hence, each of these drawing heads may turn off 25,000 feet of sliver in 12 hours.

Some manufacturers have lately introduced a double roller beam, and a double draught at the same doubling, into their drawing frames. I have seen this contrivance working satisfactorily in mills where low counts were spun, and where the tube roving frame was employed; but I was informed by competent judges, that it was not advisable where a level yarn was required for good printing calicoes.

The loss which the cotton suffers in the drawing frame is quite inconsiderable. It consists of those filaments which remain upon the drawing rollers, and collect, in a great measure, upon the flannel facing of the top and bottom cleaner bars. It is thrown among the top cleanings of the carding engine. When from some defect in the rollers, or negligence in piecing the running slivers, remarkably irregular portions occur in the ribands, these must be torn off, and returned to the lap machine to be carded anew.

The fifth operation may be called the *first spinning process*, as in it the cotton sliver receives a twist; whether the twist be permanent, as in the bobbin and fly frame, or be undone immediately, as in the tube-roving machine. In fact, the elongated slivers of parallel filaments could bear little further extension without breaking asunder, unless the precaution were taken to condense the filaments by a slight convolution, and at the same time to entwine them together. The twisting should positively go no further than to fulfil the purpose of giving cohesion, otherwise it would place an obstacle in the way of the future attenuation into level thread. The combination of drawing and twisting is what mainly characterizes the spinning processes, and with this fifth operation, therefore, commences the formation of yarn. As, however, a sudden extension to the wished-for fineness is not practicable, the draught is thrice repeated in machine spinning, and after each draught a new portion of torsion is given to the yarn, till at last it possesses the degree of fineness and twist proportioned to its use.

The preliminary spinning process is called *roving*. · At first the torsion is slight in proportion to the extension, since the solidity of the still coarse sliver needs that cohesive aid only in a small degree, and looseness of texture must be maintained to facilitate to the utmost the farther elongation.

Fig. 331 is a section of the can roving frame, the ingenious invention of Arkwright, which, till within these 14 years, was the principal machine for communicating the incipient torsion to the spongy cord furnished by the drawing heads. It differs from that frame in nothing but the twisting mechanism; and consists of two pairs of drawing rollers, *a* and *b*, between which the sliver is extended in the usual way; *c* are brushes for cleaning the rollers; and *d* is the weight which presses the upper set upon the lower. The wiping covers (not shown here) rest upon *a b*. The surface speed of the posterior or second pair of rollers is 3, 4, or 5 times greater than that of the front or receiving pair, according to the desired degree of attenuation. Two drawn slivers were generally united into one by this machine, as is shown in the figure, where they are seen coming from the two cans *e e*, to be brought together by the pressure rollers, before they reach the drawing rollers *a b*. The sliver, as it escapes from these rollers, is conducted into the revolving conical lantern *g*, through the funnel *f* at its top. This lantern-can receives its motion by means of a cord passing over a pulley *k*, placed a little way above the step on which it turns. The motion is steadied by the collet of the funnel *f*, being embraced by a brass busk. Such a machine generally contained four drawing heads, each mounted with two lanterns; in whose side there was a door for taking out the conical coil of roving.

The motion imparted to the back roller by the band pulley or rigger *m*, was conveyed to the front one by toothed wheel work.

The vertical guide pulley at bottom, *n*, served to lead the driving band descending from the top of the frame round the horizontal whorl or pulley upon the under end of the lantern. The operation of this can-frame was pleasing to behold; as the centrifugal force served both to distribute the soft cord in a regular coil, and also to condense a great deal of it most gently within a moderate space. Whenever the lantern was filled, the tenter carried the roving to a simple machine, where it was wound upon bobbins by hand. Notwithstanding every care in this transfer, the delicate texture was very apt to be seriously injured, so as to cause corresponding injuries in every subsequent operation, and in the finished yarn. Messrs. Cocker and Higgins, of Salford, had the singular merit, as I have said, of superseding that beautiful but defective mechanism, which had held a prominent place in all cotton mills from almost the infancy of the factory system, by the following apparatus.

The Bobbin and Fly frame is now the great roving machine of the cotton manufac-

re; to which may be added, for coarse spinning, the tube roving frame. Of such a complicated machine as the bobbin and fly frame, it is not possible to give an adequately detailed description in the space due to the subject in this Dictionary. Its mechanical combinations are, however, so admirable as to require such an account as will make its functions intelligible by the general reader.
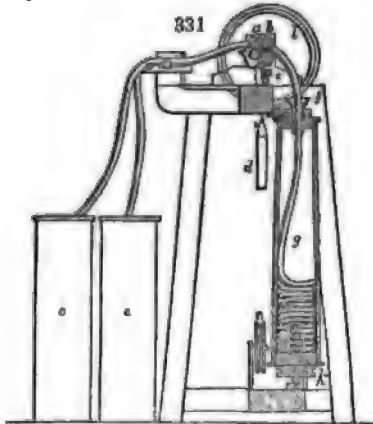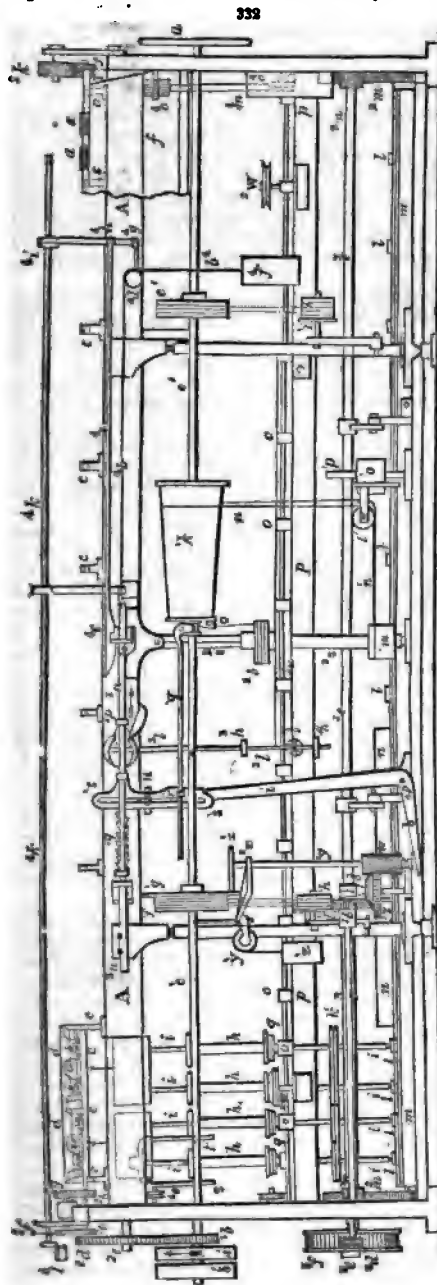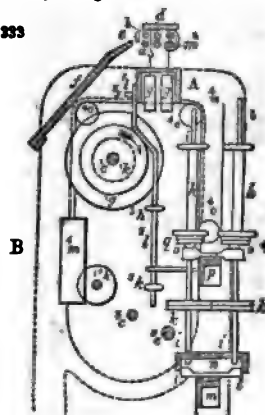
Fig. 332 exhibits a back view of this machine; and *fig.* 333 a section of some of the parts not very visible in the former figure. The back of the machine is the side at which the cotton is introduced between the drawing rollers.

The cans, or lap-bobbins filled with slivers at the drawing frame, are placed in the situation marked B, *fig.* 333, in rows parallel with the length of the machine. The sliver of each can, or the united slivers of two contiguous cans, are conducted upwards along the surface of a sloping board *f*, and through an iron staple or guide *e*, betwixt the usual triple pair of drawing rollers, the first of which is indicated by *a*, *b*. In *fig.* 332, for the purpose of simplifying the figure, the greater part of these rollers and their subordinate parts are omitted. After the slivers have been sufficiently extended and attenuated between the rollers, they proceed forwards, towards the spindles *i i i*, where they receive the twist, and are wound upon the bobbins *h*. The machine delineated contains thirty spindles, but many bobbin and fly frames contain double or even four times that number. Only a few of the spindles are shown in *fig.* 332, for fear of confusing the drawing.

With regard to the drawing functions of this machine, I have already given abundant

explanation, so far as the properties and operation of the rollers are concerned. The frame-work of this part of the machine, called the *roller-beam*, is a cast-iron bench, upon which nine bearers, *c*, are mounted for carrying the rollers. The fluted rollers *a a a, fig.* 334, are constructed in four pieces for the whole length, which are parted from each other by thinner smooth cylindric portions, *z*, called necks. Seven such partings for four rollers, and one parting for two rollers, constitute together the 30 fluted rollers of which the whole series consists. The coupling of these roller subdivisions into one cylinder, is secured by the square holes *x*, and square pins *y, fig.* 334, which fit into the
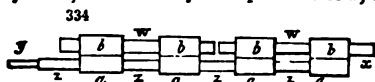
holes of the adjoining subdivision. The top or pressure rollers *b*, are two-fold over the whole set; and the weighted saddle presses upon the neck *w*, which connects every pair, as was already explained under *fig.* 329. These weights *g g, fig.* 333, are applied in this as in the *drawing frame; d* are the bars faced with flannel for cleaning the top rollers. A similar bar is applied beneath the rollers, to keep the flutings clean.

The structure and operation of the spindles *i* may be best understood by examining

the section *fig.* 335. They are made of iron, are cylindrical from the top down to *a*2, but from this part down to the steel tipped rounded points they are conical. Upon this conical portion there is a pulley *k*, furnished with two grooves in its circumference, in which the cord runs that causes the spindle to revolve. The wooden bobbin *h* is slid upon the cylindrical part, which must move freely upon it, as will be presently explained. To the bobbin another two-grooved pulley or whorl *g* is made fast by means of a pin *r*, which passes through it; by removing this pin, the bobbin can be instantly taken off the spindle. The upper end of the spindle bears a fork *s t*, which may be taken off at pleasure by means of its left-handed screw; this fork, or flier, has a funnel-formed hole at *v*. One arm of the fork is a tube, *s, u*, open at top and bottom; the leg, *t*, is added merely as a counterpoise to the other. In *fig.* 333, for the sake of clearness, the forks or fliers of the two spindles here represented are left out; and in *fig.* 332, only one is portrayed for the same reason. It is likewise manifest from a comparison of these two figures that the spindles are alternately placed in two rows, so that each spindle of the back range stands opposite the interval between two in the front range. The object of this distribution is economy of space, as the machine would need to be greatly longer if the spindles stood all in one line. If we suppose the spindles and the bobbins (both of which have independent motions) to revolve simultaneously and in the same direction, their operation will be as follows: The sliver, properly drawn by the fluted rollers, enters the opening of the funnel *v*, proceeds thence downwards through the hole in the arm of the fork, runs along its tube *u, s*, and then winds round the bobbin. This path is marked, in *fig.* 335, by a dotted line.

The revolution of the spindles in the above circumstances effects the twisting of the sliver into a soft cord; and the flier *s, t*, or particularly its tubular arm *s*, lays this cord upon the bobbin. Were the speed of the bobbins equal to that of the spindles, that is, did the bobbin and spindle make the same number of turns in the same time, the process would be limited to mere twisting. But the bobbin anticipates the fliers a little, that is, it makes in a given time a somewhat greater number of revolutions than the spindle, and thereby effects the continuous winding of the cord upon itself. Suppose the bobbin to make 40 revolutions, while the spindle completes only 30; 30 of these revolutions of the bobbin will be inoperative towards the winding-on, because the fliers follow at that rate, so that the cord or twisted sliver will only be coiled 10 times round the bobbin, and the result as to the winding-on will be the same as if the spindle had stood still, and the bobbin had made 40 — 30 = 10 turns. The 30 turns of the spindles serve, therefore, merely the purpose of communicating twist.

The mounting and operation of the spindles are obviously the same as they are upon the household flax wheel. In the bobbin and fly frame there are some circumstances which render the construction and the winding-on somewhat difficult, and the mechanism not a little complicated. It may be remarked, in the first place, that as the cord is wound on, the diameter of the bobbin increases very rapidly, and therefore every turn made round it causes a greater length of roving to be taken up in succession. Were the motions of the bobbins to continue unchanged in this predicament, the increased velocity of the winding-on would require an increased degree of extension, or it would

occasion the rupture of the cord, because the front fluted rollers move with uniform speed, and therefore deliver always the same length of sliver in the same time. It is therefore necessary to diminish the velocity of the bobbins, or the number of their turns, in the same proportion as their diameter increases, in order that the primary velocity may remain unchanged. Moreover, it is requisite for the proper distribution of the cord upon the bobbin, and the regular increase of its diameter, that two of its successive convolutions should not be applied over each other, but that they should be laid close side by side. This object is attained by the up and down sliding motion of the bobbin upon the spindle, to the same extent as the length of the bobbin barrel. This up and down motion must become progressively slower, since it increases the diameter of the bobbin at each range, by a quantity equal to the diameter of the sliver. What has now been stated generally, will become more intelligible by an example.

Let it be assumed that the drawing rollers deliver, in 10 seconds, 45 inches of roving, and that this length receives 30 twists. The spindles must, in consequence, make 30 revolutions in 10 seconds, and the bobbins must turn with such speed, that they wind up the 45 inches in 10 seconds. The diameter of the bobbin barrels being 1½ inches, their circumference of course 4½ inches, they must make 10 revolutions more in the same time than the spindles. The effective speed of the bobbins will be thus 30+10=40 turns in 10 seconds. Should the bobbins increase to 3 inches diameter, by the winding-on of the sliver, they will take up 9 inches at each turn, and consequently 45 inches in 5 turns. Their speed should therefore be reduced to 30+5=35 turns in 10 seconds. In general, the excess in number of revolutions, which the bobbins must make over the spindles, is inversely as the diameter of the bobbins. The speed of the bobbins must remain uniform during the period of one ascent or descent upon the spindle, and must diminish at the instant of changing the direction of their up and down motion; because a fresh range of convolutions then begins with a greater diameter. When, for example, 30 coils of the sliver or roove are laid in one length of the bobbin barrel, the bobbin must complete its vertical movement up or down, within 30 seconds in the first case above mentioned, and within 60 seconds in the second case.

The motions of the drawing rollers, the spindles, and bobbins, are produced in the following manner:—A shaft c', *figs.* 332 and 333, extending the whole length of the machine, and mounted with a fly wheel d', is set in motion by a band from the running pulley upon the shaft of the mill, which actuates the pulley a'. b' is the loose pulley upon which the band is shifted when the machine is set at rest. Within the pulley a', but on the outside of the frame, the shaft c carries a toothed wheel b^2 with 50 teeth, which by means of the intermediate wheel c^2 turns the wheel d^2 upon the prolonged shaft of the backmost fluted roller (m^2, *fig.* 333.) This wheel d^2 has usually 54 teeth; but it may be changed when the roove is to receive more or less twist; for as the spindles revolve with uniform velocity, they communicate the more torsion the less length of sliver is delivered by the rollers in a given time. Upon the same shaft with d^2, a pinion e^2 of 32 teeth is fixed, which works in a wheel f^2 of 72 teeth. Within the frame a change pinion g^2 is made fast to the shaft of f^2. This pinion, which has usually from 24 to 28 teeth, regulates the drawing, and thereby the fineness or *number* of the roving. It works in a 48-toothed wheel h^2 upon the end of the backmost fluted roller a, *fig.* 333. The other extremity of the same roller, or, properly speaking, line of rollers, carries a pinion l^2, furnished with 26 teeth, which, by means of the broad intermediate wheel k^2, sets in motion the pinion i^2 of 22 teeth upon the middle roller. When the diameter of all the drawing rollers is the same, suppose 1 inch, their proportional velocities will be, with the above number of teeth in the wheel work, if g^2 have 24 teeth, as 1 : 1·18 : 4·5; and the drawn sliver will have 4½ times its original length. The front or delivery roller of the drawing frame is of late years usually made 1¼ or 1½ inches in diameter. If 625 feet of the sliver from the drawing frame weighed one pound, 2790 feet of the roving will now go to this weight, and the number will be 1·12; that is, 1 hank and 12 hundredths to the pound. The front pair of fluted rollers makes about 90 revolutions, and delivers 282·6 inches of roving in the minute, when of one inch diameter.

The spindles i (*figs.* 332 and 333), rest, with their lower ends, in steps l, which are fixed in an immoveable beam or bar m. To protect it from dust and cotton filaments, this beam is furnished with a wooden cover n, in which there are small holes for the passage of the spindles right over the steps. In *fig.* 332, two of the eight covers n, which compose the whole range m, are removed to let the steps be seen. The cylindrical part of each spindle passes through a brass ring o; and all these 30 rings, whose centres must be vertically over the steps l, are made fast to the copping beam p. This beam is so called, because it is destined not merely to keep the spindles upright by the rings attached to it, but, at the same time, to raise and lower along the spindles the bobbins

which rest on these rings; for which purpose the two racks, or toothed bars are so made fast to it, are designed, as will be presently explained. To effect the revolution of the spindles, there are attached to the main shaft c' two wheels or pulleys c' f', each bearing four grooves of equal diameter. Each of these pulleys puts one half of the spindles in motion, by means of a cord, which, after going round the wheels k, turns four times about the pulleys of the shaft c'. Two guide pulleys, each four-grooved, and two others i', with a single groove, which turn independently of the others, upon the above shaft, serve to give the whorl cords the proper direction, as well as to keep them tight. The spindles revolve 200 times or thereby in the minute; and therefore impart two turns or twists to every three inches of the roving.

The revolution of the bobbins is independent of that of the spindles, although it likewise proceeds from the shaft c', and differs from it in being a continually retarded motion. The simplest method of effecting this motion, is by means of the wooden or tin plate cone k'', which revolves equally with the shaft c', and at the same time slides along it.

The manner in which this operates is shown in section in fig. 336. Here we perceive the rod q², which extends from the base toward the narrow end of the truncated cone, and p² a forked bearer or carrier made fast to the shaft c' by a screw, which compels the cone, by means of that rod, to obey the movements of c'. In the large end
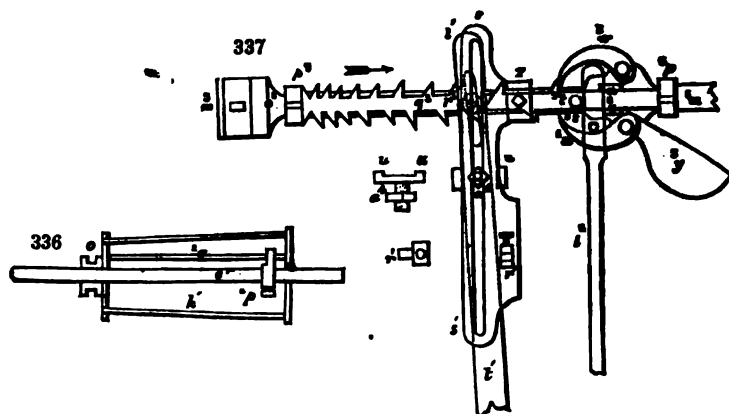
of the cone there is an aperture, through which the bearer can be got at. The smaller end carries outside a projection o², provided with a groove, which is embraced by the forked end of a rod q', fig. 337, that serves to shove the cone along upon the shaft c'. Directly under the cone, there is an upright round pillar p', upon which the holder o' of the two guide pulleys l' is adjustable. A bar r² placed along-side of the holder, prevents its turning round, but allows it to slide along p' by friction. The weight of the holder and the pulley is sufficient to distend the endless band n', which runs from the cone k', through under the pulley l', and round the small drum m' on the shaft s². A pulley or whorl t², with four grooves, is made fast by means of a tube to this shaft, and slides along it backwards and forwards, without ever ceasing to follow its revolutions. The shaft possesses for this purpose a long fork, and the interior of the tube a corresponding tongue or catch. There is besides upon the tube beneath the pulley, at u², a groove that goes round it, in which the staple or forked end of an arm like v², fig. 333, made fast to the copping beam p, catches. By the up and down movement of that beam, the pulley t² takes along with it the arm that embraces the tube, which therefore rises and falls equally with the bobbins h', and their pulleys or whorls q. This is requisite, since the bobbins are made to revolve by the pulleys t², by means of two endless cords or bands.

The most intricate part of the mechanism is the adjustment, by which the revolution of the bobbins is continually retarded, and their up and down, or copping motion, along the spindles, is also retarded in like proportion. The vertical pulley f' (towards the left end of the shaft c) has at its right side a somewhat larger disc or sheave f, with a perfectly uniform, but not a very smooth surface. Upon this sheave, a smaller horizontal pulley x' rubs, whose upper face is covered with leather to increase the friction. The under end of the shaft y² of the pulley x' turns in a step, which is so connected with the arm v' of the large bent lever t' v', that it always stands horizontally, whatever direction the arms of that lever may assume. The shaft y² is steadied at top by an

ιπιlar holder or bush, which embraces the fast arm x^2 with its forked end. Upon its opposite side, this arm carries a pulley y^2, upon which a cord goes, that is made fast to e holder of the shaft y^2, and loaded with the weight z'. The weight presses the ιlley z' against the surface of g', in such wise as to effect the degree of friction necessary order that the revolution of g' may produce an uninterrupted revolution in x'. A aion w', whose length must be equal at least to the semi-diameter of the sheave g', is seed upon the under end of the shaft y^2. It has 22 teeth, and takes into a 62-toothed rizontal wheel z^2. Upon the upper end of this wheel the conical pinion a^3 is made st, which may be changed for changing the speed, but usually has from 28 to 30 teeth. r this pinion the conical wheel b^3 is turned, which has 30 teeth, and whose shaft is c^3. his shaft carries upon its opposite end a six-leaved pinion, d^3, which takes into the lender wheel f^3, formed with cogs like a trundle, upon the long shaft e^3. In *fig.* 338 e wheel f^3 is exhibited with its pinion d^3. Here we may remark, that in the circum-ιence of the wheel there is a vacant place, g^3, void of teeth. When, by the motion of e wheel, the pinion comes opposite to this opening, it turns round about the last tooth the wheel, falls into the inside of the toothed circle marked by the dotted lines, and ιs gives now an inverse movement to the wheel f^3, while itself revolves always in the ne direction. This reversed motion continues till the opening g^3 comes once more
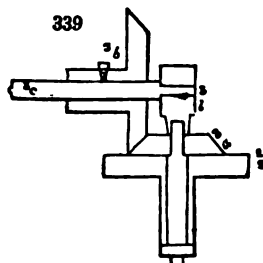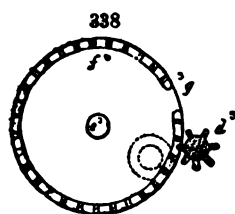
ιosite to the pinion, when this turns round about the last tooth of that side, and begins ιin to work in the exterior teeth. Thus, by the uniform motion of d^3 and its ιendant parts, the wheel f^3, with its shaft e^3, revolves alternately to the right hand l the left. That this result may ensue, the shaft c^3 of the pinion must be able to e endwise, without losing its hold of a^3 and b^3. This adjustment is effected by cing the end of the said shaft, nearest b^3, in a box or holder i^3, in which it can turn, l which forms a vertical tube to this box, as a downward prolongation which is fixed the tail of the conical pinion a^3. *Fig.* 339 shows this construction in section upon enlarged scale. The second bearer of the shaft nearest d^3, must possess likewise the ans of lateral motion. When therefore the pinion d^3 shifts through the opening the wheel f^3 outwards or inwards, its shaft c^3, makes a corresponding small angular ιon upon the pivot of a^3, by means of the tube i^3; a^3 and b^3 remain thereby com-tely in gear with one another.

Γhe above-described alternate revolutions of the wheel f^3 serve to produce the up l down motions of the bobbins. The shaft e^3 has for this purpose two pinions n^2 m^2, ich work in the rack teeth m^2 m^2 of the copping rail p, and thus alternately raise and k it with the bobbins which rest upon it. The weight of the copping beam and all dependant parts, is poised by two counterweights m^4, whose cords run over the leys o^4 o^4 o^4, *fig.* 332, and have their ends made fast to the frame, so as to make the ιard motion as easy as the downward. The two upper pulleys out of the three of h weight are fixed to the frame; the under one, round which the cord first runs, is ιched to the copping beam, rising and falling along with it.

ιs long as the friction disc x' remains at the same height, the pulley g' derives its ιion from the same circle of the said disc, and the up and down motion of the copping ιn is also uniform. But when that disc ascends so as to describe with its edge a small ιle upon the face of g', its motion must become proportionally more slow. This is the ιhod, or principle of retarding the copping motions of the bobbins. It has been shown, ιever, that the rotation of the bobbins should be also retarded in a progressive manner. ιs object is effected by means of the cone k', which, as the band n progressively ιroaches towards its smaller diameter, drives the pulleys or whorls q of the bobbins ι decreasing speed, though itself moves uniformly quick with the shaft c. To effect ι variation, the cone is shifted lengthwise along its shaft, while the band running ιn it remains continually in the same vertical plane, and is kept distended by the ιght of the pulley o'. The following mechanism serves to shift the cone, which may ι best understood by the aid of the figures 340, 841, and 337. A long cast iron bar a^2,

which bears two horizontal projecting puppets, o^3 o^3, is made fast to the front upright face of the copping beam A. Through the above puppets a cylindrical rod n^3 passes freely,

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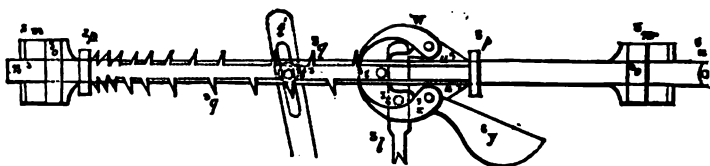
341

which is left out in *fig.* 337, that the parts lying behind it may be better seen. Upon this rod there is a kind of fork, p^3 p^3, to which the alternating rack bars q^3 are made fast. The teeth of these racks are at unequal distances from each other, and are so arranged, that each tooth of the under side corresponds to the space between two teeth in the upper side. Their number depends upon the number of coils of roving that may be required to fill a bobbin; and consists in the usual machines of from 20 to 22. The rod n^3 may be shifted in the puppet o^3, like the fork p^3 of the rack-rod, upon the rod n^3, and along the surface of m^3, where two wings u^3 u^3 are placed, to keep the fork in a straight direction. Upon the bar m^3, there are the pivots or fulcra of two stop catches w^3 x^3, of which the uppermost presses merely by its own weight, but the undermost by means of a counterweight y^3, against the rack, and causes them thus to fall in between the teeth. In *fig.* 341, v^4 shows the pivot of the catch or detent w^3 by itself, the detent itself being omitted, to render the construction plainer. A pushing rod h, upon which there is a pin above at s^3, that passes behind the rack rod, between this and the bar m^3, has for its object to remove at pleasure the one or the other of the two catches; the upper, when the upper end of the rod pushes against it; the under, by means of the above mentioned pin s^3. Both the catches are never raised at once, but either the under or the upper holds the rack bar fast, by pressing against one of the teeth. The vertical motion up or down, which the rod l^3 must take to effect the lifting of the catches, is given to it from the copping beam p; since upon it a horizontal arm v^2, *fig.* 341, is fixed, that lays hold of that rod. Upon the pushing rod are two rings, h^3 and k^3, each made fast by a screw. When the copping beam is in the act of going up, the arm v^3 at the end of this movement, pushes against the ring h^3, raises up the rod l^3, and thus removes the catch w^3, *fig.* 337, from the teeth of the rod q^3, before which it lies flat. At the descent of the copping rail, v^2 meets the ring k^3, when the motion in this direction is nearly completed, draws down the rod l^3 a little, by means of the same, and thereby effects the removal of the catch x^3, *fig.* 337, from the rod q^3. Every time that one of the catches is lifted, the rack recovers its freedom to advance a little bit in the direction of the arrow; so far, namely, till the other catch lays hold upon the tooth that next meets it. The reason is thus manifest why the teeth of the upper and under sides of the bar q^3 are not right opposite to each other, but in an alternate position.

From the rack-bar, the sliding of the cone k', and the raising of the shaft y^2, each by minute steps at a time, is produced as follows: —

A large rectangular lever t^1, v^1, whose centre of motion is at p^4, has at the upper end of its long arm t^1, a long slot through which a stud r^3 upon the rack q^3 goes, (*figs.* 340, 341, 337,) so that the lever must follow the motions of the rack bar. The end of the short arm of the lever bears, as already mentioned, the step of the shaft y^2; hence the friction disc x^1 will be raised in proportion as the rack bar advances, and will come nearer to the middle point of g^1; consequently, its revolution and the shifting of the bobbins will become slower. Upon the cylindrical rod n^3, the piece s^1 s^1 furnished with a long slot is made fast, by means of a tube z^2, (*fig.* 337,) and a screw. A fork u u, which by means of the screw nut a^4 is made fast in the slot, embraces the arm t^1 of the bent lever; and a tube r^1 riveted to the surface of s^1, is destined to take up the draw rod q^1 of the cone k^1, *fig.* 337. A weight f^4, whose cord b^4 is made fast to the cylindrical rod n^3, endeavors to draw this rod continually in the direction of the arrow. In consequence of this arrangement, every time that the pushing bar l^3 lifts up one of the catches, the cone k^1, the lever t^1 v^1, and by it the rack bar q^3, are set in motion. It is

obvious, that the motion of the cone may be made greater or less, according as the fork *u u* is fixed further up or down in the slot of *s¹*.

The number of the teeth upon the bar *q³* is so ordered, that the bobbins are quite full when the last tooth has reached the catch and is released by it. The rack bar, being restrained by nothing, immediately slides onwards, in consequence of the traction of the weight *f⁴*, and brings the machine to repose by this very movement, for which purpose the following construction is employed. A rectangular lever which has its centre of motion in *g⁴* is attached to the side face of the beam A, and has at the end of its horizontal arm a pulley *d⁴*, over which the cord *b⁴* of the counterweight *f⁴* is passed. The end of the perpendicular arm is forked and embraces the long and thin rod *k⁴*, to whose opposite end the fork *l⁴* is made fast. Through this fork the band which puts the machine in motion passes down to the pulley *a¹*. With the bent lever another rod *c⁴* is connected at *h⁴*, which lies upon the puppet *e³* with a slot at *e⁴*, and hereby keeps the lever *g⁴* in its upright position notwithstanding the weight *f⁴*. In the moment when, as above stated, the rack bar *q³* becomes free, the arm *p³* of its fork pushes in its rapid advance against the under oblique side of *e⁴*, raises this rod, and thereby sets the lever *g⁴* free, whose upright arm bends down by the traction of the weight, drives the rod *k⁴* before it into the ring *i⁴* fastened to it, and thus, by means of the fork *l⁴*, shifts the band upon the loose pulley *b¹*. But the machine may be brought to repose or put out of gear at any time merely by shifting the rod *k⁴* with the hand.

The operation of the bobbin and fly frame may be fully understood from the preceding description. A few observations remain to be made upon the cone *k¹*, the rack-bar *q³*, and the speed of the work.

When we know the diameter of the empty bobbins, and how many turns they should make in a given time in order to wind-on the sliver delivered by the fluted rollers and the spindles; when we consider the diameters of the spindle pulleys *q*, and *t²*, as also the drum *m¹*, *fig.* 332, we may easily find the diameter which the cone must have for producing that number of turns. This is the diameter for the greatest periphery of the base. The diameter of the smaller is obtained in the same way, when the diameter of the bobbins before the last winding-on, as well as the number of turns necessary in a given time, are known.

A bobbin and fly frame of the construction just described delivers from each spindle in a day of twelve hours, from 6 to 8 lbs. of roving of the fineness of 1½ English counts. One person can superintend two frames, piece the broken slivers, and replace the full bobbins by empty ones. The loss of cotton wool in this machine consists in the portions carried off from the torn slivers, and must be returned to the lapping machine.

The fine bobbin and fly frame does not differ essentially from the preceding machine. The rovings from the coarse bobbin and fly frame are placed in their bobbins in a frame called the *creel*, behind and above the roller beam, two bobbins being allowed for one fluted portion of the rollers. These rovings are united into one, so as to increase the uniformity of the slivers.

The invention of the beautiful machine above described is due to Messrs. Cocker and Higgins, of Manchester, and as lately improved by Henry Houldsworth, jun., Esq., it may be considered the most ingeniously combined apparatus in the whole range of productive industry.

In the fine roving frame the sliver is twisted in the contrary direction to that of the coarse roving frame. For this reason the position of the cone is reversed, so as to present in succession to the band, or strap, diameters continually greater, in order that the rotation of the bobbins may be accelerated in proportion as their size is increased, because here the flier and the bobbin turn in the same direction, and the winding-on is effected by the precession of the bobbin; but if the winding-on took place by its falling behind, as in the coarse bobbin and fly frame, that is, if the flier turned less quickly than the bobbin, the rotatory speed of the bobbin would be uniformly retarded; in which case the cone would be disposed as in the coarse frame.

When, by any means whatever, a uniform length of thread is delivered by the rollers in a given time, the bobbin must wind it up as it is given out, and must therefore turn with a speed decreasing with the increase of its diameter by successive layers of thread. Hence proceeds the proposition, that the velocity of the bobbin must be in the inverse ratio of its diameter, as already explained.

With respect to the bobbin and fly frame, the twist is given to the sliver by means of a spindle, or flier, which turns in the same direction with the bobbin, but quicker or slower than it, which establishes two predicaments. The first case is where the flier turns faster than the bobbin. Here the winding-on goes in advance, as in the coarse roving frame, or as in throstle spinning, where the yarn is wound on merely in consequence of the friction of the lower disc or washer of the bobbin upon the copping rail, and of the drag of the yarn. The second case is where the flier revolves more slowly than the bobbin. Here the winding goes on in arrear, and as the bobbin

turns faster, it must receive a peculiar motion, which is uniformly retarded in the ratio of its increase of diameter. This is the case with the fine bobbin and fly frame. When the cone is placed as in *fig.* 332, the winding-on, in either the coarse or fine frame, results from the difference, whether greater or less, between the rotatory speed of the flier and bobbin.

The motion of the bobbin and spindle is simultaneous, and takes place in the same direction, with a difference varying more or less with the varying diameters of the bobbins. To render the matter still clearer, suppose for a moment the spindle to be motionless, then the bobbin must revolve with such a speed as to lap-on the roving as fast as the rollers deliver it. The sliver comes forward uniformly; but the bobbin, by its increase of diameter, must revolve with a speed progressively slower. Now, suppose the spindle set a-whirling, it is obvious that the bobbin must add to the movement requisite for winding-on the sliver, that of the spindle in the case of winding-on in arrear, or when it follows the fliers, and subtract its own motion from the twisting motion of the spindles, in the case of winding-on in advance, that is, when the bobbin precedes or turns faster than the fliers; for the diameter of the bobbin being 1½ inches, 10 turns will take up 45 inches. Deducting these 10 turns from the 30 made by the spindle in the same time, there will remain for the effective movement of the bobbin only 20 turns; or when the diameter of the bobbin becomes 3 inches, 5 turns will take up the 45 inches, if the spindle be at rest; but if it makes 30 turns in the time, the effective velocity of the bobbin will be 25 turns, $= 30 - 5$. Hence in the fine bobbin and fly frame, the number of turns of the spindle, *minus* the number of turns made by the bobbin in equal times, is in the inverse ratio of the diameter of the bobbin. We thus perceive, that in the coarse frame the bobbin should move faster than the spindle, and that its speed should always diminish; whilst in the fine frame the bobbin should move slower than the spindle, but its speed should always increase. It is easy to conceive, therefore, why the cones are placed in reverse directions in the two machines. Not that this inversion is indispensably necessary; the cone of the fine roving frame might, in fact, be placed like that of the coarse roving frame; but as the torsion of the roving becomes now considerable, and as on that account the bobbin would need to move still faster, which would consume a greater quantity of the moving power, it has been deemed more economical to give its movement an opposite direction.

We mentioned that the twist of the sliver in the fine roving frame was the reverse of that in the coarse; this is a habit of the spinners, for which no good reason has been given.

The divisions of the rack-bar, and the successive diameters of the cone, must be nicely adjusted to each other. The first thing to determine is, how much the rack should advance for every layer or range of roving applied to the bobbin, in order that the cone may occupy such a place that the strap which regulates the pulley barrel may be at the proper diameter, and thus fulfil every condition. The extent of this progressive movement of the rack depends upon the greater or less taper of the cone, and the increase which the diameter of the bobbin receives with every traverse, that is, every layer of roving laid on. But care should be taken not to taper the cone too rapidly, especially in the fine roving frame, because in its progress towards the smaller end the strap would not slide with certainty and ease. We have already shown that the number of effective turns of the bobbin is inversely, as the diameter of the bobbin; or directly, as the successive diameters of the different points of the cone.

H. Houldsworth, jun. Esq. has introduced a capital improvement into the bobbin and fly frame, by his differential or equation-box mechanism, and by his spring fingers, which, by pressing the soft sliver upon the bobbin, cause at least a double quantity to be wound upon its barrel. With the description of his patent equation-box, I shall conclude the description of the bobbin and fly frame.

Fig. 342 represents a portion of a fly frame with Mr. Houldsworth's invention. *a a a* are the front drawing rollers, turning upon bearings in the top of the machine, and worked by a train of toothed wheels, in the way that drawing rollers are usually actuated.

From the drawing rollers, the filaments of cotton or other material, *b b*, are brought down to, and passed through the arms of the fliers *c c*, mounted on the tops of the spindles *d d*, which spindles also carry the loose bobbins *e e*. In the ordinary mode of constructing such machines, the spindles are turned by cords or bands passing from a rotatory drum round their respective pulleys or whirls *f*, and the loose bobbins *e*, turn with them by the friction of their slight contact to the spindle, as before said; in the improved machine, however, the movements of the spindles and the bobbins are independent and distinct from each other, being actuated from different sources.

The main shaft of the engine *g*, turned by a band and rigger ▲ as usual, communicates motion by a train of wheels *h*, through the shaft *i*, to the drawing rollers at the reverse end of the machine, and causes them to deliver the filaments to be twisted.

Upon the main shaft g, is mounted a cylindrical hollow box or drum-pulley, whence one cord passes to drive the whirls and spindles f and d, and another to drive the bobbins e.
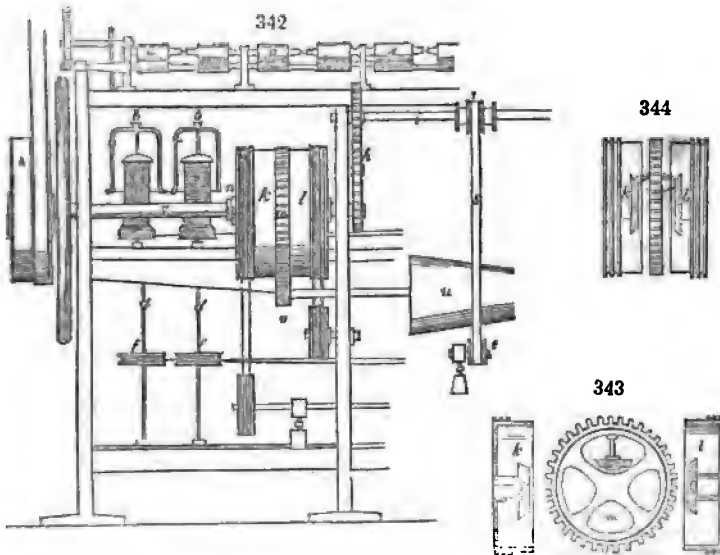
This cylindrical box pulley is made in two parts, k and l, and slipped upon the axle with a toothed wheel m, intervening between them. The box and wheel are shown detached in fig. 343, and partly in section at fig. 344. That portion of the box with its pulley marked l, is fixed to the shaft g; but the other part of the box and its pulley k, and the toothed wheel m, slide loosely round upon the shaft g, and when brought in contact and confined by a fixed collar n, as in the machine shown at fig. 342, they constitute two distinct pulleys, one being intended to actuate the spindles, and the other the bobbins.

In the web of the wheel m, a small bevel pinion o, is mounted upon an axle standing at right angles to the shaft g, which pinion is intended to take into the two bevel pinions p and q, respectively fixed upon bosses, embracing the shaft in the interior of the boxes k and l. Now it being remembered that the pinion q, and its box l, are fixed to the shaft g, and turn with it, if the loose wheel m be independently turned upon the shaft, with a different velocity, its pinion o, taking into q, will be made to revolve upon its axle, and to drive the pinion p, and pulley box k, in the same direction as the wheel m; and this rotatory movement of the box k and wheel m, may be faster or slower than the shaft g, and box l, according to the velocity with which the wheel m is turned.

Having explained the construction of the box pulleys k and l, which are the peculiar features of novelty claimed under this patent, their office and advantage will be seen by describing the general movements of the machine.

The main shaft g, being turned by the band and rigger A, as above said, the train of wheels h, connected with it, drives the shaft i, which at its reverse end has a pinion (not seen in the figure) that actuates the whole series of drawing rollers a. Upon the shaft i there is a sliding pulley r, carrying a band s, which passes down to a tension pulley t, and is kept distended by a weight. This band s, in its descent, comes in contact with the surface of the cone u, and causes the cone to revolve by the friction of the band running against it. The pulley r is progressively slidden along the shaft i, by means of a rack and weight not shown, but well understood as common in these kind of machines, and which movement of the pulley is for the purpose of progressively shifting the band s from the smaller to the larger diameter of the cone, in order that the speed of its rotation may gradually diminish as the bobbins fill by the winding-on of the yarns.

At the end of the axle of the cone u a small pinion r is fixed, which takes into the teeth of the loose wheel m, and, as the cone turns, drives the wheel m round upon the shaft g, with a speed dependant always upon the rapidity of the rotation of the cone. Now the box pulley l, being fixed to the main shaft g, turns with one uniform speed, and by cords passing from it over guides to the whorls f, drives all the spindles and fliers, which twist the yarns with one continued uniform velocity; but the box pulley k,

being loose upon the shaft, and actuated by the bevel pinions within, as described, is made to revolve by the rotation of the wheel *m*, independent of the shaft, and with a different speed from the pulley box *l*; cords passing from this pulley box *k*, over guides to small pulleys under the bobbins, communicate the motion, whatever it may be, of the pulley box *k*, to the bobbins, and cause them to turn, and to take up or wind the yarn with a speed derived from this source, independent of, and different from, the speed of the spindle and flier which twist the yarn.

It will now be perceived, that these parts being all adjusted to accommodate the taking up movements to the twisting or spinning of any particular quality of yarn intended to be produced, any variations between the velocities of the spinning and taking up, which another quality of yarn may require, can easily be effected, by merely changing the pinion *r*, for one with a different number of teeth, which will cause the wheel *m*, and the pulley box *k*, to drive the bobbins faster or slower, as would be required in winding-on fine or coarse yarn, the speed of the twisting or spinning being the same.

The rovings or spongy cords, of greater or less tenuity, made on the bobbin and fly, or tube roving frame, are either spun immediately into firm cohesive yarn, or receive a further preparation process in the stretching frame, which is, in fact, merely a mule-jenny, without the second draught and second speed, and therefore need not be described at present, as it will be in its place afterwards.

The *finishing machines* of a cotton mill, which spin the cohesive yarn, are of two classes; 1. the water-twist or throstle, in which the twisting and winding are performed simultaneously upon progressive portions of the roving; and, 2. the mule, in which the thread is drawn out and stretched, with little twist, till a certain length of about 5 feet is extended, then the torsion is completed, and the finished thread is immediately wound upon the spindles into double conical coils called cops.

The water-twist frame, so called by its inventor, Sir R. Arkwright, because it was first driven by water, is now generally superseded by the throstle frame, in which the mechanical spinning fingers, so to speak, are essentially the same, but the mode of communicating the motion of the mill-gearing to them is somewhat different. *Fig.* 345 exhibits a vertical section of the throstle. This machine is double, possessing upon each side of its frame a row of spindles with all their subsidiary parts. The bobbins, filled with rovings from the bobbin and fly, or the tube frame, are set up in the creel *a a*, in two ranges. *b, c, d*, are the three usual pairs of drawing rollers, through which the yarn is attenuated to the proper degree of fineness, upon the principles already explained. At its escape from the front rollers, every thread runs through a guide eyelet *e* of wire, which gives it the vertical direction down towards the spindles *f, g*. The spindles which perform at once and uninterruptedly the twisting and winding-on of the thread delivered by the rollers, are usually made of steel, and tempered at their lower ends. They stand at *g* in steps, pass at *e* through a brass bush or collet which keeps them upright, and revolve with remarkable speed upon their axes. The bobbins *h*, destined to take up the yarn as it is spun, are stuck loosely upon the spindles, and rest independently of the rotation of the spindles upon the copping beam *l*, with a leather washer between. Upon the top of the spindles an iron-wire fork, called a fly or flier, *i, k*, is made fast by a left-hand screw, and has one of its forks turned round at the end into a little ring. The branch of the flier at *f* is tubular, to allow the thread to pass through, and to escape by a little hole at its side, in order to reach the eyelet at the end of that fork. From this eyelet *i*, it proceeds directly to the bobbin. By the twirling of the spindle, the twisting of the portion of thread between the front roller *d* and the nozzle *f* is effected. The winding-on takes place in the following way:—Since the bobbin has no other connexion with the spindle than that of the thread, it would, but for it, remain entirely motionless, relatively to the spindle. But the bobbin is pulled after it by the thread, so that it must follow the rotation of the spindle and fly. When we consider that the thread is pinched by the front roller *d*, and is thereby kept fully upon the stretch, we perceive that the rotation of the bobbin must be the result. Suppose now the tension to be suspended for an instant, while the rollers *d* deliver, for example, one inch of yarn. The inertia or weight of the bobbin, and its friction upon the copping beam *l*, by means of the leather washer, will, under this circumstance, cause the bobbin to hang back in a state of rest, till the said inch of yarn be wound on by the whirling of the fly *i*, and the former tension be restored. The delivery of the yarn by the drawing rollers, however, does not take place inch after inch, by starts, but at a certain continuous rate; from whence results a continuous retardation or loitering, so to speak, of the bobbins behind the spindles, just to such an amount that the delivered yarn is wound up at the same time during the rotation.

This process in spinning is essentially the same as what occurs in the fine bobbin and fly frame, but is here simplified, as the retardation regulates itself according to the diameter of the bobbin by the drag of the thread. In the fly frame the employment

of this tension is impossible, because the roving has too little cohesion to bear the strain; and hence it is necessary to give the bobbins that independent movement of rotation which so complicates this machine.

The up and down motion of the bobbins along the spindles, which is required for the equal distribution of the yarn, and must have the same range as the length of the bobbin barrels, is performed by the following mechanism. Every copping rail, *l*, is made fast to a bar *m*, and this, which slides in a vertical groove or slot at the end of the frame, is connected by a rod *n*, with an equal-armed, moveable lever *o*. The rod *p* carries a weight *r*, suspended from this lever; another rod, *q*, connects the great lever *o* with a smaller one *s*, *t*, upon which a heart-shaped disc or pulley, *u*, works from below at *t*. By the rotation of the disc *u*, the arm *t*, being pressed constantly down upon it by the reaction, the weight *r* must alternately rise and fall; and thus the copping rail *l* must obviously move with the bobbins *h* up and down; the bobbins upon one side of the frame rising, as those upon the other sink. Strictly considered, this copping motion should become slower as the winding-on proceeds, as in the fly roving frame; but, on account of the smallness of the finished thread, this construction, which would render the machine complicated, is without inconvenience neglected, with the result merely that the coils of the yarn are successively more sparsely laid on, as the diameter of the bobbin increases.

The movement of the whole machine proceeds from the shaft of a horizontal drum, which drives the spindles by means of the endless bands *x x*. Each spindle is mounted with a small pulley or wharf, *w*, at its lower part, and a particular band, which goes round that wharf or whorl, and the drum *y*. The bands are not drawn tense, but hang down in a somewhat slanting direction, being kept distended only by their own weight. Thus every spindle, when its thread breaks, can readily be stopped alone, by applying a slight pressure with the hand or knee, the band meanwhile gliding loosely round the whorl.

The velocities of rotation of the three drawing rollers are, according to this arrangement, in the proportion of $1 : 1\frac{1}{2} : 8$; and as their diameters are the same, namely, one inch, the elongation of the yarn in spinning is eight-fold. If, for example, the roving was of the number $4\frac{1}{2}$, the yarn would become No. 36. The extension of the thread may be changed by changing the wheels of the drawing rollers. To perceive the power of this change, let us put, for example, in the place of the 18-toothed wheel of the back rollers, a wheel with 16 teeth; we shall find that the elongation will amount, in that case, only to $7\frac{1}{2}$ times, whence the number of the yarn would come out $32 = 7\frac{1}{2} \times 4\frac{1}{2}$. The extension by the throstle is extremely various: it amounts, in some cases, to only 4 times; at others to 10, 12, or even 15.

The copping motion of the bobbins is produced in consequence of a bevel pinion working in a small bevel wheel upon an upright shaft; while this wheel gives a slow motion by means of a worm screw to the wheel of the heart-shaped pulley *u*, *fig*. 345.

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The driving pulley makes about 600 turns in a minute; and as the diameter of the drum *y*, *fig*. 345, is six times the diameter of the spindle wharves *w*, it will give 3600 turns to the spindle in that time. If the pulley be driven faster, for example, 700 times in a minute, it will increase the revolutions of the spindles to 4200. The degree of twist which will be thereby imparted to the yarn, depends, with like speed of spindles, upon the rate at which the soft yarn is delivered by the drawing-rollers; for the quicker this delivery the quicker is the winding-on, and the less twist goes into a given length of yarn. If, for example, the front rollers *d* turn 24 times in a minute, giving out of course 72 inches of yarn in this time, upon which the 3600 revolutions of the spindle are expended, there will be 50 twists to every inch of yarn. By changing the wheel-work of *fig*. 345, or by sticking greater or smaller wharves upon the spindles, the proportion between their velocity and that of the drawing rollers, and thence the degree of twist, can be modified at pleasure.

The number of spindles in a throstle frame 12 feet long is about 60 on each side. The drawing rollers are coupled together as in the bobbin and fly frame, so that each row forms one continuous cylinder. There is a complete roller beam on each side; each of the rollers of the front row is pressed by its top rollers with a weight of ten or

twelve pounds; but those of the middle and back rows bear weights of only one pound. In the throstles, there is a guide bar which traverses a small way horizontally to the left and right, in front of the roller beam, to lead the thread along different points of the rollers, and thus prevent the leather of the top ones from being grooved by its constant pressure in one line.

For the service of 240 spindles, in two double frames, one young woman and an assistant piecer are sufficient. They mend the broken ends, and replace the empty bobbins in the creel with full ones, and the full bobbins of the throstle by empty ones. The average quantity of yarn turned off in a week of 69 hours is about 24 hanks per spindle of 30's twist. Throstle yarn is of a firm wiry quality, adapted to the warps of fustians and other strong stuffs, as well as to the manufacture of stockings and sewing thread.

There are many modifications of the throstle system besides the one above described; the most celebrated of which are Danforth's, called the American throstle, Montgomery's, and Gore's. I must refer for an account of them to my work entitled "The Cotton Manufacture of Great Britain," where they are minutely described and illustrated with accurate figures.

Mule-spinning.—The general principles of the mule have been already stated. This machine is so named because it is the offspring, so to speak, of two older machines, the jenny and the water-frame. A mule is mounted with from 240 to 1000 spindles, and spins, of course, as many threads.
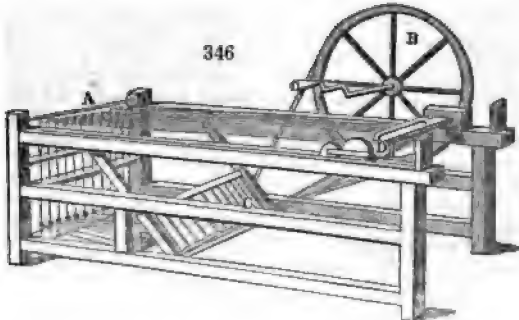
Fig. 346 represents the original *jenny* of Hargreaves, by which one person was enabled to spin from 16 to 40 threads at once. The soft cords of rovings wound in double conical cops upon skewers were placed in the inclined frame at c; the spindles for first twisting and then winding-on the spun yarn were set upright in steps and bushes at A, being furnished near their lower ends with whorls, and endless cords, which were driven by passing round the long-revolving drum of tin plate E. D is the clasp or clove, having a handle for lifting its upper jaw a little way, in order to allow a few inches of the soft roving to be introduced. The compound clove D being now pushed forward upon its friction wheels to A, was next gradually drawn backward, while the spindles were made to revolve with proper speed by the right hand of the operative turning the fly-wheel B. Whenever one *stretch* was thereby spun, the clove frame was slid home towards A; the spindles being simultaneously whirled slowly to take up the yarn, which was laid on in a conical cop by the due depression of the faller wire at A with the spinner's left hand.

Fig. 347 is a diagram of Arkwright's original *water - frame* spinning machine, called afterwards the *water - twist*

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frame. The rovings mounted upon bobbins in the creel A A, have their ends led through between the three sets of twin rollers below B B, thence down through the eyelet hooks upon the end of the fliers of the spindles C, and finally attached to their bobbins. The spindles being driven by the band D D upon their lower part, continuously twist and wind the finished yarn upon the bobbins; constituting the first unremitting automatic machine for spinning which the world ever saw.

Contrast with the above admirable system, the primitive cotton wheel of India, as represented in the annexed figure 348. By the aid of mechanical fingers, one Englishman at his mule can turn off daily more yarn and of far finer quality than 200 of the most diligent spinsters of Hindostan.

Fig. 349 is a transverse section of the mule, in which its principal parts are shown.

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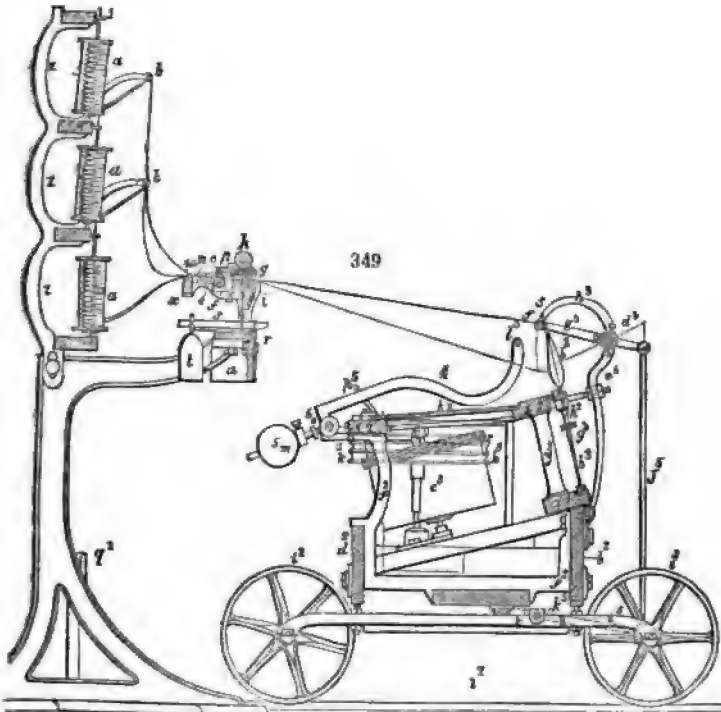
The machine consists of two main parts; a fixed one corresponding in some measure to the water-frame or throstle, and a moveable one corresponding to the jenny. The first contains in a suitable frame the drawing roller-beam and the chief moving machinery: the second is called the carriage, in which the remainder of the moving mechanism and the spindles are mounted.

The frame of the fixed part consists of two upright sides, and two or more intermediate parallel bearings, upon which the horizontal roller beam *a*, the basis of the drawing rollers is supported. *b, c, d,* are the three ranges of fluted iron rollers; *e, f, g,* are the upper iron rollers covered with leather; *h,* the wooden wiper-rollers covered with flannel, which being occasionally rubbed with chalk, imparts some of it to the pressure rollers beneath, so as to prevent the cotton filaments adhering to them. The rollers are made through-

out the whole length of the mule in portions containing six flutings, which are coupled together by squared ends fitted into square holes.

The skewers upon which the bobbins containing the rovings from the bobbin and fly or stretching frame are set up, are seen at a^1, a^1, a^1, arranged in three rows in the creel z. The soft threads unwound from these bobbins, in their way to the drawing rollers, pass first through eyelets in the ends of the wire arms b^1, then through the rings or eyes of the guide bar w, and enter between the back pair of rollers. The number of these bobbins is equal to the number of spindles in the mule, and twice as great as the number of fluted portions of the rollers; for two threads are assigned to each portion.

The carriage consists of two cast-iron side pieces, and several cast-iron intermediate similar pieces, such as f^2, which all together are made fast to the planks b^2, c^2, d^2. The top is covered in with the plank k^2. The carriage runs by means of its cast-iron grooved wheels, upon the cast-iron railway l^2, which is fixed level on the floor.

The spindles stand upon the carriage in a frame, which consists of two slant rails x^2, x^2, connected by two slender rods y^2, and which frame may be set more or less obliquely. The lower rail carries the brass steps for the points of the spindles b^3; upon the upper rail brass slips are fixed pierced with holes through which the tops of the spindles play. The spindles are as usual made of steel, perfectly straight, turned truly round, and are all arranged in one plane. To each of them a small wooden or cast-iron whorl g^2 is made fast. They are distributed into groups of 24, and the whorls are arranged at such different heights, that only two of them in each group are upon a level with each other. A small brass head h^2, which every spindle has beneath the upper slant rail of the frame x^2, prevents their sitting down into the step, during their rotation, or sliding off their cop of yarn.

c^3 are drums, mounted in the carriage in a plane at right angles to the plane in which the spindles are placed. At top they have a double groove for a cord to run in, and the motion which they receive from the great fly wheel, or rim of the mule (not visible in this view) they impart to the spindles. Such a drum is assigned to every 24 spindles; and therefore a mule of 480 spindles contains 20 drums. In the middle of the carriage is seen the horizontal pulley k^3, furnished with three grooves, which stands in a line with the drums c^3.

The motion is given to the drums c^3, upon the right hand half of the carriage, by a single endless band or cord which proceeds from the middle groove of the pulley k^3. The rotation of the spindles is produced by a slender cord, of which there are 12 upon each drum c^3; because every such cord goes round the drum, and also every two wharves which stand at the same level upon the spindles. It is obvious that the drums, and consequently the spindles, must continue to revolve as long as the main rim of the mule is turned, whether the carriage be at rest or in motion upon its railway.

If we suppose the carriage to be run in to its standing point, or to be pushed home to the spot from which it starts in spinning, its back plank d^2 will strike the post q^3 upon the fixed frame, and the points of the spindles will be close in front of the roller beam. The rollers now begin to turn and to deliver threads, which receive immediately a portion of their twist from the spindles; the carriage retires from the roller beam with somewhat greater speed than the surface speed of the front rollers, whereby the threads receive a certain degree of stretching, which affects most their thicker and less twisted portions, and thereby contributes greatly to the levelness of the yarn. When the carriage has run out to the end of its course, or has completed a stretch, the fluted rollers suddenly cease to revolve (and sometimes even beforehand, when a second stretch is to be made), but the spindles continue to whirl till the fully extended threads have received the proper second or after-twist. Then the carriage must be put up, or run back towards the rollers, and the threads must be wound upon the spindles.

This is the order of movements which belong to the mule. It has been shown how the rotation of the spindles is produced.

For winding-on the yarn the carriage has a peculiar apparatus, which we shall now describe. In front of it, through the whole extent to the right hand as well as the left, a slender iron rod, d^5, runs horizontally along, in a line somewhat higher than the middle of the copping portion of the spindles, and is supported by several props, such as e^5. Upon each end of the two rods, d^5, there is an arm, g^5; and betwixt these arms an iron wire, called the copping wire, f^5, is stretched, parallel with the rod d^5. For the support of this wire, there are several slender bent arms h^5 extended from the rod d^5 at several points betwixt the straight arms g^5. The rod d^5 has, besides, a wooden handle at the place opposite to where the spinner stands, by which it can be readily grasped. This movement is applied at the left division of the machine, and it is communicated to the right by an apparatus which resembles a crane's bill. The two arms, g^6, in the middle of the machine, project over the rods d^5, and are connected by hinges with two vertical rods j^5, which hang together downwards in like manner with two arms i^5, proceeding from a horizontal axis k^5.

By means of that apparatus the yarn is wound upon the spindles in the following manner. As long as the stretching and twisting go on, the threads form an obtuse angle with the spindles, and thereby slide continually over their smooth rounded tips during their revolution, without the possibility of coiling upon them. When, however, the spinning process is completed, the spinner seizes the carriage with his left hand and pushes it back towards the roller beam, while with his right hand he turns round the handle of the rim or fly wheel, and consequently the spindles. At the same time, by means of the handle upon the rod d^5, he moves the copping-wire f^5, so that it presses down all the threads at once, and places them in a direction nearly perpendicular to the spindles; as shown by the dotted line y^5. That this movement of the copping wire, however, may take place without injury to the yarn, it is necessary to turn the rim beforehand a little in the opposite direction, so that the threads may get uncoiled from the upper part of the spindles, and become slack; an operation called in technical language the *backing off*. The range upon which the threads should be wound, in order to form a conical cop upon the spindle, is hit by depressing the copping wire to various angles, nicely graduated by an experienced eye. This faller wire alone is not, however, sufficient for the purpose of winding-on a seemly cop, as there are always some loose threads which it cannot reach without breaking others.

Another wire called the *counter-faller*, l^5, must be applied under the threads. It may be raised to an elevation limited by the angular piece p^5; and is counterpoised by a very light weight m^5, applied through the bent lever n^5, which turns upon the fulcrum o^5. This wire, which applies but a gentle pressure, gives tension to all the threads, and brings them regularly into the height and range of the faller f^5. This wire must be raised once more, whenever the carriage approaches the roller beam. At this instant a new stretch commences; the rollers begin again to revolve, and the carriage resumes its former course. These motions are performed by the automatic machinery.

There is a little eccentric pulley mechanism for moving the guide beam to and fro with the soft yarns, as they enter between the back rollers. On the right hand end of the back roller shaft, a worm screw is formed which works into the oblique teeth of a pinion attached to the end of the guide beam, in which there is a series of holes for the passage of the threads, two threads being assigned to each fluted roller. In the flat disc of the pinion, an eccentric pin stands up which takes into the jointed lever upon the end of the guide beam, and, as it revolves, pushes that beam alternately to the left and the right by a space equal to its eccentricity. This motion is exceedingly slow, since for each revolution of the back roller, the pinion advances only by one tooth out of the 33 which are cut in its circumference.

After counting the number of teeth in the different wheels and pinions of the mule, or measuring their relative diameters, it is easy to compute the extension and twist of the yarns; and when the last fineness is given to ascertain their marketable value. Let the ratio of speed between the three drawing rollers be $1 : 1\frac{3}{27} : 7\frac{1}{2}$; and the diameter of the back and middle roller three quarters of an inch: that of the front roller one inch; in which case the drawing is thereby increased $1\frac{1}{2}$ times, and $7\frac{1}{2} \times 1\frac{1}{2} = 10$. If the rovings in the creel bobbins have been No. 4, the yarn, after passing through the rollers, will be No. 40. By altering the change pinion (not visible in this view) the fineness may be changed within certain limits, by altering the relative speed of the rollers. For one revolution of the great rim or fly wheel of the mule, the front roller makes about 6 tenths of a turn, and delivers therefore 22·6 lines or 12ths of an inch of yarn, which, in consequence of the tenfold draught through the rollers, corresponds to 2·26 lines of roving fed in at the back rollers. The spindles or their whorls make about 66 revolutions for one turn of the rim. The pulleys or grooved wheels on which the carriage runs, perform 0·107 part of a turn while the rim makes one revolution, and move the carriage 24·1 lines upon its rails, the wheels being 6 inches in diameter.

The 22·6 lines of soft yarn delivered by the front rollers will be stretched $1\frac{1}{2}$ lines by the carriage advancing 24·1 lines in the same time. Let the length of the railway, or of each stretch, be 5 feet, the carriage will complete its course after 30 revolutions of the rim wheel, and the 5 feet length of yarn (of which $56\frac{1}{2}$ inches issue from the drawing rollers, and $3\frac{1}{2}$ inches proceed from the stretching) is, by the simultaneous whirling of the spindles, twisted 1980 times, being at the rate of 33 twists for every inch. The second twist, which the threads receive after the carriage has come to repose, is regulated according to the quality of the cotton wool, and the purpose for which the yarn is spun. For warp yarn of No. 40 or 50, for example, 6 or 8 turns of the rim wheel, that is, from 396 to 528 whirls of the spindles for the whole stretch, therefore from 7 to 9 twists per inch will be sufficient. The finished yarn thus receives from 40 to 42 twists per inch.

One spinner attends to two mules, which face each other, so that he needs merely turn round in the spot where he stands, to find himself in the proper position for the other mule. For this reason the rim wheel and handle, by which he operates, are not

placed in the middle of the length of the machine, but about two fifths of the spindles are to the right hand and three fifths to the left; the rim wheel being towards his right hand. The carriage of the one mule is in the act of going out and spinning, while that of the other is finishing its twist, and being put up by the spinner.

The quantity of yarn manufactured by a mule in a given time, depends directly upon the number of the spindles, and upon the time taken to complete every stretch of the carriage. Many circumstances have an indirect influence upon that quantity, and particularly the degree of skill possessed by the spinner. The better the machine, the steadier and softer all its parts revolve, the better and more abundant is its production. When the toothed wheels do not work truly into their pinions, when the spindles shake in their bushes, or are not accurately made, many threads break, and the work is much injured and retarded. The better the staple of the cotton wool, and the more careful has been its preparation in the carding, drawing, and roving processes, the more easy and excellent the spinning will become : warmth, dryness, cold, and moisture have great influence on the ductility, so to speak, of cotton. A temperature of 65° F., with an atmosphere not too arid, is found most suitable to the operations of a spinning mill. The finer the yarn, the slower is the spinning. For numbers from 20 to 36, from 2 to 3 stretches of warp may be made in a minute, and nearly 3 stretches of weft; for numbers above 50 up to 100, about 2 stretches; and for numbers from 100 to 150, one stretch in the minute. Still finer yarns are spun more slowly, which is not wonderful, since, in the fine spinning mills of England, the mules usually contain upwards of 500 spindles each, in order that one operative may manage a great number of them, and thereby earn such high wages as shall fully remunerate his assiduity and skill.

In spinning fine numbers, the second speed is given before the carriage is run out to the end of its railway ; during which course of about six inches, it is made to move very slowly. This is called the second stretch, and is of use in making the yarn level by drawing down the thicker parts of it, which take on the twist less readily than the thinner, and therefore remain softer and more extensible. The stretch may therefore be divided into three stages. The carriage first moves steadily out for about 4 feet, while the drawing rollers and spindles are in full play ; now the rollers stop, but the spindles go on whirling with accelerated speed, and the carriage advances slowly about 6 inches more; then it also comes to rest, while the spindles continue to revolve for a little longer, to give the final degree of twist. The acceleration of the spindles in the second and third stages, which has no other object but to save time, is effected by a mechanism called the *counter*, which shifts the driving band, at the proper time, upon the loose pulley, and, moreover, a second band, which had, till now, lain upon its loose pulley, upon a small driving pulley of the rim-shaft. At length, both bands are shifted upon their loose pulleys, and the mule comes to a state of quiescence.

The SELF-ACTOR MULE, or the IRON MAN, as it has been called in Lancashire, is an invention to which the combinations among the operative spinners obliged the masters to have recourse. It now spins good yarn up to 40s with great uniformity and promptitude, and requires only juvenile hands to conduct it, to piece the broken yarns, to replace the bobbins of rovings in the creel, and to remove the finished cops from the spindles.

The self-acting mules were first constructed, I believe, by Messrs. Eaton, formerly of Manchester, who mounted ten or twelve of them in that town, four at Wiln, in Derby-shire, and a few in France. From their great complexity and small productiveness, the whole were soon relinquished, except those at Wiln. M. de Jong obtained two patents for self-acting mules, and put twelve of them in operation in a mill at Warrington, of which he was part proprietor; but with an unsuccessful result. I saw the *débris* of one of M. de Jong's self-actors in the factory of M. Nicholas Schlumberger, at Guebwiller — in Alsace, where the machine had been worked for three months, without advantage — under the care of the inventor, who is a native of that valley.

The first approximation to a successful accomplishment of the objects in view, was an invention of a self-acting mule, by Mr. Roberts, of Manchester; one of the principal points of which was the mode of governing the winding-on of the yarn into the form of a cop; the entire novelty and great ingenuity of which invention was universally admitted, and proved the main step to the final accomplishment of what had so long been desideratum. For that invention a patent was obtained in 1825, and several headstocks upon the principle were made, which are still working successfully.

In 1830, Mr. Roberts obtained a patent for the invention of certain improvements and by a combination of both his inventions, he produced a self-acting mule, which is generally admitted to have exceeded the most sanguine expectations, and which has been extensively adopted. There are probably, at present, upwards of half a million of spin-dles of Messrs. Sharp, Roberts, and Co.'s construction, at work in the United Kingdom and giving great satisfaction to their possessors. The advantages of these self-actors are the following :—

aving of a spinner's wages to each pair of mules, piecers only being required,
verlooker is sufficient to manage six or eight pairs of mules. The production
ater quantity of yarn, in the ratio of from 15 to 20 per cent. The yarn pos-
more uniform degree of twist, and is not liable to be strained during the spin-
in winding-on, to form the cop; consequently, fewer threads are broken in these
s, and the yarn, from having fewer piecings, is more regular.
ops are made firmer, of better shape, and with undeviating uniformity; and, from
ore regularly and firmly wound, contain from one third to one half more yarn
is of equal bulk wound by hand; they are consequently less liable to injury in
or in carriage, and the expense of packages and freight (when charged by
ment) is considerably reduced.
the cops being more regularly and firmly wound, combined with their superior
n, the yarn intended for warps less frequently breaks in winding or reeling, con-
y there is a considerable saving of waste in those processes.
lly, the advantages connected with weaving.
ops being more regularly and firmly wound, the yarn, when used as weft, sel-
aks in weaving; and as the cops also contain a greater quantity of weft, there
er bottoms, consequently there is a very material saving of waste in the process
ing.
those combined circumstances, the quality of the cloth is improved, by being
e from defects caused by the breakage of the warp or weft, as well as the sel-
ing more regular.
ooms can also be worked at greater speed; and, from there being fewer stop-
greater quantity of cloth may be produced.
he advantages thus enumerated, as derivable from the use of self-acting mules,
t been overrated, but, in many instances, have been considerably exceeded, I
extensive personal inquiry and observation, had ample opportunity of ascer-

lent of the quantity of yarn produced on Messrs. Sharp, Roberts, and Co.'s self-
ules, in twelve working hours, including the usual stoppages connected with
, estimated on the average of upwards of twenty mills:—

o. of Yarn.	No. of Twist.	No. of Weft.
16	4½ hanks	4¼ hanks per spindle.
24	4¼ —	4⅜ —
32	4 —	4⅝ —
40	3¾ —	4¼ —

: intermediate numbers the quantities are proportionate.
s of trials made by Messrs. Sharp, Roberts, and Co., at various mills, to ascer-
comparative power required to work self-acting mules, in reference to hand-
uring the spinning, up to the period of backing off.

Particulars of the trials referred to, and their results:—

Mill, and the Description of Mule.	No. and kind of Yarn.	Diameter of Pulley or Rim Wheel.	Revolutions of Pulley or Rim Wheel.	Required Force for Motion.	Total Force Employed in Spinning.
		Ins.		lbs.	lbs.
rrs. Birley and Kirk. Weft.					
ing mule, 360 sps. - -	30 to 34	12	58	30	5463
-mule, 180 sps. - - -	ditto	15	36	26	3669 ×2=7338
s. Leech and Vandrey. Twist.					
cting mule, 324 sps. -	36	12	70	36	7912
nules, 324 sps. - - -	36	29	58	16½	7273
rrs. Duckworth & Co. Twist.					
ting mule, 324 sps. -	40	12	62	33	6421
nule, 324 sps. - - -	40	47	36	15¼	6646

lode adopted to make the trials was as follows, viz.:
e, indicated by weight in pounds, was applied to the strap working upon the

ial was disadvantageous for the hand-mules, being two for 360 spindles.
ial was disadvantageous for the self-acting mules, being driven by a very short and light vertical
hand-mul having a long horizontal strap.

driving-pulley of the respective mules, sufficient to maintain the motion of the mule whilst spinning, which weight, being multiplied by the length of strap delivered by each revolution of the pulley, and again by the number of revolutions made by the pulley whilst spinning, gave the total force in pounds, applied to the respective mules whilst spinning ; for instance, suppose a mule to be driven by a pulley 12 inches diameter (3·14 feet in circumference), such pulley making 58 revolutions during the spinning as above, and that it required a force equal to 30 lbs. weight to maintain the motion of the mule, then 30 lbs. × 3·14 feet circumference of pulley × 58 revolutions in spinning = 5,463 lbs. of force employed during the spinning, to the period of backing off.

Mr. James Smith, of Deanstone cotton works in Scotland, obtained a patent for the invention of a *self-actor*, in February, 1834. He does not perform the backing-off by reversing the rotation of the spindle, as in common mules, or as in Mr. Roberts', but by elevating the counterfaller wire, which, being below the ends of the yarn or thread, along the whole extent of the carriage, thereby pulls off or strips the spiral coils at the point of the spindle, instead of unwinding them, as of old. This movement he considers to be of great importance towards simplifying the machinery for rendering the mule self-acting ; and the particular way in which he brings the stripper into action is no doubt ingenious, but it has been supposed by many to strain the yarn. He claims as his invention the application and adaptation of a mangle wheel or mangle rack to the mule, for effecting certain successive movements, either separately or in conjunction; he claims that arrangement of the carriages of a pair of mules, by which the stretch is caused to take place over part of the same ground by both carriages, and thereby the space required for the working of the pair of mules is greatly diminished; and he claims the application of a weight, spring, or friction, for balancing the tension of the ends of the threads.

A patent was granted, in April, 1835, to Mr. Joseph Whitworth, engineer in Manchester, for some ingenious modifications of the mechanism of the mule, subservient to automatic purposes. His machinery is designed, first, to traverse the carriage in and out, by means of screws or worm-shafts, which are placed so as to keep the carriage parallel to the drawing rollers, and prevent the necessity of squaring bands, hitherto universally employed : secondly, his invention consists in an improved manner of working the drums of a self-acting mule by gear; thirdly, in the means of effecting the backing off; fourthly, in the mechanism for working the faller-wire in building the cops; and fifthly, in the apparatus for effecting the winding of the yarns upon the spindles. As regards the throstles and doubling frames, his improvements apply, first, to the peculiar method of constructing and adapting the flyers and spindles, and producing the drag ; and, secondly, to the arrangement of the other parts of the doubling machinery.

See Lace-Making, Singeing, Textile Fabric, Thread Manufacture, and Weaving.

The Imports of Cotton Wool for home consumption into the United Kingdom were, in the year ending 5th January—

	1836.	1837.
	lbs.	lbs.
From the British possessions in America - - - - -	1,346,220	1,011,434
do. do. East Indies - - - -	43,404,058	34,060,055
United States of America - - - - - - -	287,346,721	309,027,306
Brazil - - - - - - - - - - - - -	26,879,779	20,822,509
Egypt - - - - - - - - - - - - -	5,184,743	7,465,774
Otherwise imported - - - - - - - - - - -	6,789,603	5,602,602
Total - - - - - - - - -	370,951,124	378,019,680
	£	£
The Exports of Cotton Manufactures - - - - - -	18,511,692	13,625,464
— Yarn - - - - - - - - -	6,120,366	6,953,467

COURT PLASTER is a considerable object of manufacture. It is made as follows— Black silk is strained and brushed over ten or twelve times with the following preparation :—Dissolve ½ an ounce of balsam of benzoin in 6 ounces of rectified spirits of wine ; and in a separate vessel dissolve 1 ounce of isinglass in as little water as may be. Strain each solution, mix them, and let the mixture rest, so that any undissolved part may subside ; when the clear liquid is cold it will form a jelly, which must be warmed before it is applied to the silk. When the silk coated with it is quite dry, it must be

d off with a coat of a solution of 4 ounces of Chian turpentine in 6 ounces of
e of benzoin, to prevent its cracking.*

APE. (*Crèpe*, Fr.; *Krepp*, Germ.) A transparent textile fabric, somewhat
uze, made of raw silk, gummed and twisted at the mill. It is woven with any
g or tweel. When dyed black, it is much worn by ladies as a mourning dress.
s are crisped (*crepés*) or smooth; the former being double, are used in close
ing, the latter in less deep. White crape is appropriate to young unmarried
s, and to virgins on taking the veil in nunneries. The silk destined for the
spun harder than for the second; since the degree of twist, particularly of the
determines the degree of crisping which it assumes after being taken from the

It is for this purpose steeped in clear water, and rubbed with prepared wax.
s are all woven and dyed with the silk in the raw state. They are finished with
ening of gum water.

pe is a Bolognese invention, but has been long manufactured with superior
ence at Lyons in France, and Norwich in England. There is now a magnificent
of it at Yarmouth, by power-loom machinery.

re is another kind of stuff, called *crepon*, made either of fine wool, or of wool and
f which the warp is twisted much harder than the weft. The *crepons* of Naples
t altogether of silk.

AYONS. (Eng. and Fr.; *Pastelstifte*, Germ.) Slender, soft, and somewhat
cylinders, variously colored for delineating figures upon paper, usually called
drawings. Red, green, brown, and other colored crayons, are made with fine
or china clay paste, intimately mixed with earthy or metallic pigments, or in
il with body or surface colors, then moulded and dried. The brothers Joel, in
employ as crayon cement the following composition: 6 parts of shellac, 4 parts
rit of wine, 2 parts of turpentine, 12 parts of a coloring powder, such as Prussian-
rpiment, white lead, vermilion, &c., and 12 parts of blue clay. The clay being
ited, passed through a hair sieve, and dried, is to be well incorporated by tritu-
with the solution of the shellac in the spirit of wine, the turpentine, and the
nt; and the doughy mass is to be pressed in proper moulds, so as to acquire the
d shape. They are then dried by a stove heat.

rder to make cylindrical crayons, a copper cylinder is employed, about 2 inches
meter, and 1½ inches long, open at one end, and closed at the other with a per-
d plate, containing holes corresponding to the sizes of the crayons. The paste is
uced into the open end, and forced through the holes of the bottom by a piston
l by a strong press. The vermicular pieces that pass through are cut to the
r lengths, and dried. As the quality of the crayons depends entirely upon the
ss of the paste, mechanical means must be resorted to for effecting this object in
est manner. The following machine has been found to answer the purpose exceed
well.
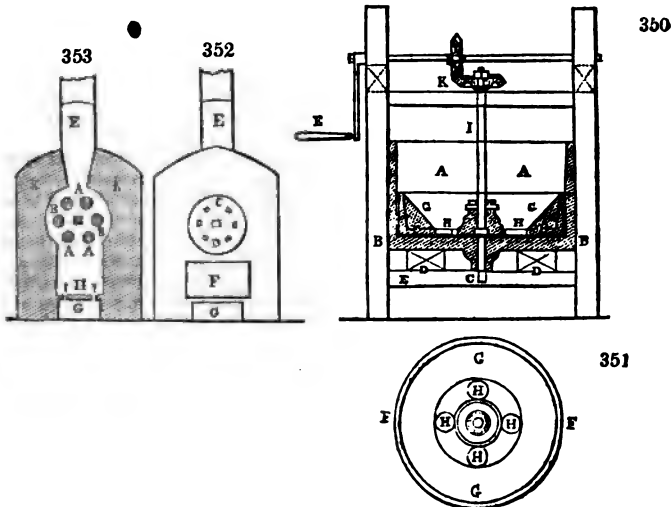
Fig. 350 is a vertical section through the centre of the crayon mill. *Fig.* 351 is a view of the mill from above. A, the mill tub, whose bottom B must be a hard flat plate of cast-iron; the sides A being of wood or iron at pleasure. In the centre of the bottom there is a pivot c, screwed into a socket cast upon the bottom, and which may be strengthened by two cross bars D, made fast to the frame E. F, the millstone of cast-iron, concave, whose diameter is considerably smaller than that of the vessel A; it is furnished within with a circular basin of wood G, which receives the materials to be ground, and directs them to the holes H, which allow them to pass down between the under part of the muller, and the bottom of the tub, to undergo trituration.

By the centrifugal motion, the paste is driven towards the sides of the vessel, rises over the sides of the muller, and comes again through the holes H, so as to be repeatedly subjected to the grinding operation. This millstone is mounted upon an upright shaft I, which receives rotatory motion from the bevel wheel work K, driven by the winch L.

The furnace in which some kinds of crayons, and especially the factitious blacklead pencils are baked, is represented in *fig.* 352 in a front elevation; and in *fig.* 353, which is a vertical section through the middle of the chimney.

A A, six tubes of greater or less size, according as the substance of the crayons is a better or worse conductor of heat. These tubes, into which the crayons intended for baking are to be put, traverse horizontally the laboratory B of the furnace, and are supported by two plates c, pierced with six square holes for covering the axes of the tubes A. These two plates are hung upon a common axis D; one of them, with a ledge, shuts the cylindrical part of the furnace, as is shown in the figure. At the extremity of the bottom, the axis D is supported by an iron fork fixed in the brickwork; at the front it crosses the plate c, and lets through an end about four inches square to receive a key, by means of which the axis D may be turned round at pleasure, and thereby the two plates c, and the six tubes A, are thus exposed in succession to the action of the fire in an equal manner upon each of their sides. At the two extremities of the furnace are two chimneys E, for the purpose of diffusing the heat more equably over the body of the crayons. F, *fig.* 352, is the door of the fire-place, by which the fuel is introduced; G, *fig.* 353, the ash-pit; H, the fire-place; I, holes of the grate which separate the fire-place from the ash-pit; K, brickwork exterior to the furnace.

General Lomet proposes the following composition for red crayons. He takes the softest hematite, grinds it upon a porphyry slab; and then carefully elutriates it. He makes it into a plastic paste with gum arabic and a little white soap, which he forms by moulding, as above, through a syringe, and drying, into crayons. The proportions of the ingredients require to be carefully studied.

CRAYONS, *lithographic.* Various formulæ have been given for the formation of these crayons. One of these prescribes, white wax, 4 parts; hard tallow-soap, shellac, of each 2 parts; lamp black, 1 part. Another is, dried tallow soap and white wax, each 6 parts; lamp black, 1 part. This mixture, being fused with a gentle heat, is to be cast into moulds for forming crayons of a proper size.

CREOSOTE, or the *flesh-preserver,* from κρεας and σωζω, is the most important of the five new chemical products obtained from wood tar by Dr. Reichenbach. The other four, *paraffine, eupione, picamar,* and *pittacal,* have hitherto been applied to no use in the arts, and may be regarded at present as mere analytical curiosities.

Creosote may be prepared either from tar or from crude pyroligneous acid. The tar must be distilled till it acquires the consistence of pitch, and at the utmost till it begins to exhale the white vapors of paraffine. The liquor which passes into the receiver divides itself into 3 strata, a watery one in the middle, placed between a heavy and a light oil. The lower stratum alone is adapted to the preparation of creosote.

1. The liquor, being saturated with carbonate of potash, is to be allowed to settle, and the oily matter which floats at top is to be decanted off. When this oil is distilled, it affords, at first, products lighter than water, which are to be rejected, but the heavier oil which follows is to be separated, washed repeatedly by agitation, with fresh portions of dilute phosphoric acid, to free it from ammonia, then left some time at rest, after which it must be washed by water from all traces of acidity, and finally distilled along with a new portion of dilute phosphoric acid, taking care to *cohobate,* or pour back the distilled product repeatedly into the retort.

2. The oily liquid thus rectified is colorless; it contains much *creosote,* but at the same time some *eupione,* &c. It must therefore be mixed with potash ley at 1·12 sp. grav., which dissolves the creosote. The upione floats upon the surface of that solution, and may be decanted off. The alkaline solution is to be exposed to the air, till it blackens by decomposition of some foreign matter. The potash being then saturated with dilute sulphuric acid, the creosote becomes free, when it may be decanted or syphoned off and distilled.

3. The treatment by potash, sulphuric acid, &c., is to be repeated upon the brownish

eosote till it remains colorless, or nearly so, even upon exposure to air. It must be re dissolved in the strongest potash ley, subjected to distillation anew, and, lastly, re-stilled with the rejection of the first products which contain much water, retaining only e following, but taking care not to push the process too far.

In operating upon pyroligneous acid, if we dissolve effloresced sulphate of soda in it to turation, at the temperature of 167° F., the creosote oil will separate, and float upon e surface. It is to be decanted, left in repose for some days, during which it will part ith a fresh portion of the vinegar and salt. Being now saturated while hot, with carmate of potash, and distilled with water, an oily liquor is obtained, of a pale yellow lor. This is to be rectified by phosphoric acid, &c., like the crude product of creosote oun tar.

Creosote is apparently composed of 76·2 carbon, 7·8 hydrogen, and 16·0 oxygen, in 100 arts. It is an oily looking liquid, slightly greasy to the touch, void of color, having an erid burning taste, and capable of corroding the epidermis in a short time. It possesses penetrating disagreeable smell, like that of highly smoked hams, and, when inhaled up ne nostrils, causes a flow of tears. Its specific gravity is 1·037, at 58° F. Its consistaee is similar to that of oil of almonds. It has no action upon the colors of litmus or armeric, but communicates to white paper a stain which disappears spontaneously in a ew hours, and rapidly by the application of heat.

It boils without decomposition at 398° F., under the average barometric pressure, emains fluid at 16° F., is a non-conductor of electricity, refracts light powerfully, and arns in a lamp with a ruddy smoky flame.

When mixed with water at 58° F. it forms two different combinations, the first being a olution of 1 part of creosote in 400 of water; the second, a combination of 1 part of vater with 10 parts of creosote. It unites in all proportions with alcohol, hydric ether, teetic ether, naptha, eupione, carburet of sulphur, &c.

Creosote dissolves a large quantity of iodine and phosphorus, as also of sulphur with he aid of heat, but it deposites the greater part of them in crystals, on cooling. It combines with potash, soda, ammonia, lime, baryta, and oxyde of copper. Oxyde of mercury converts creosote into a resinous matter, while itself is reduced to the metallic state. Strong sulphuric and nitric acids decompose it.

Creosote dissolves several salts, particularly the acetates, and the chlorides of calcium and tin; it reduces the nitrate and acetate of silver. It also dissolves indigo blue; a remarkable circumstance. Its action upon animal matters is very interesting. It coagulates albumen, and prevents the putrefaction of butchers' meat and fish. For this purpose these substances must be steeped a quarter of an hour in a weak watery solution of creosote, then drained and hung up in the air to dry. Hence Reichenbach has inferred that it is owing to the presence of creosote that meat is cured by smoking; but he is not correct in ascribing the effect to the mere coagulation of the albumen, since *fibrine* alone, without creosote, will putrefy in the course of 24 hours, during the heats of summer. It kills plants and small animals. It preserves flour paste unchanged for a long time.

Creosote exists in the tar of beech-wood, to the amount of from 20 to 25 per cent., and in crude pyroligneous acid, to that of 1½.

It ought to be kept in well-stoppered bottles, because when left open it becomes progressively yellow, brown, and thick.

Creosote has considerable power upon the nervous system, and has been applied to the teeth with advantage in odontalgia, as well as to the skin in recent scalds. But its medicinal and surgical virtues have been much exaggerated. Its flesh-preserving quality is rendered of little use, from the difficulty of removing the rank flavor which it imparts.

CRUCIBLES (*Creusets*, Fr.; *Schmelztiegel*, Germ.) are small conical vessels, narrower at the bottom than the mouth, for reducing ores in docimasy by the dry analysis, for fusing mixtures of earthy and other substances, for melting metals, and compounding metallic alloys. They ought to be refractory in the strongest heats, not readily acted upon by the substances ignited in them, not porous to liquids, and capable of bearing considerable alternations of temperature without cracking; on which account they should not be made too thick. The best crucibles are formed from a pure fire clay, mixed with finely ground *cement* of old crucibles, and a portion of black-lead or graphite. Some pounded coke may be mixed with the plumbago. The clay should be prepared in a similar way as for making pottery ware; the vessels after being formed must be slowly dried, and then properly baked in the kiln. Crucibles formed of a mixture of 8 parts in bulk of Stourbridge clay and cement, 5 of coke, and 4 of graphite, have been found to stand 23 meltings of 76 pounds of iron each, in the Royal Berlin foundry. Such crucibles resisted the greatest possible heat that could be produced, in which even wrought iron was melted, equal to 150° or 155° Wedgewood; and bore sudden cooling without cracking. Another composition for brass-founding crucibles is the following :—⅓ Stourbridge clay; ⅓ burned clay cement; ⅓ coke powder; ⅓ pipe

clay. The pasty mass must be compressed in moulds. The Hessian crucibles from Great Almerode and Epterode are made from a fire clay which contains a little iron, but no lime; it is incorporated with silicious sand. The dough is compressed in a mould, dried, and strongly kilned. They stand saline and leaden fluxes in docimastic operations very well; are rather porous on account of the coarseness of the sand, but are thereby less apt to crack from sudden heating or cooling. They melt under the fusing point of bar iron. Beaufay in Paris has lately succeeded in making a tolerable imitation of the Hessian crucibles with a fire clay found near Namur in the Ardennes.

Berthier has published the following elaborate analyses of several kinds of crucibles:—

	Hessian.	Beaufay.	English for Cast Steel.	St. Etienne for Cast Steel.	Glass Pots at Nemours.	Bohemian Glass Pots.	Glass Pots of Cresot.
Silica - - -	70·9	64·6	63·7	65·2	67·4	68·0	68·0
Alumina - -	24·8	34·4	20·7	25·0	32·0	29·0	28·0
Oxyde of Iron -	3·8	1·0	4·0	7·2	0·8	2·2	2·0
Magnesia - -	trace	–	–	trace	trace	0·5	trace
Water - - -	–	–	10·3 *	–	–	–	1·0

Wurzer states the composition of the sand and clay in the Hessian crucibles as follows:—

Clay; silica 10·1; alumina 65·4; oxydes of iron and manganese 1·2; lime 0·3; water 23
Sand;   95·6   2·1   1·5   0·8

Black lead crucibles are made of two parts of graphite and one of fire clay; mixed with water into a paste, pressed in moulds, and well dried; but not baked in the kiln. They bear a higher heat than the Hessian crucibles, as well as sudden changes of temperature; have a smooth surface, and are therefore preferred by the melters of gold and silver. This compound forms excellent small or portable furnaces.

Mr. Anstey describes his patent process for making crucibles, as follows: Take two parts of fine ground raw Stourbridge clay, and one part of the hardest gas coke, previously pulverized, and sifted through a sieve of one eighth of an inch mesh (if the coke is ground too fine the pots are very apt to crack). Mix the ingredients together with the proper quantity of water, and tread the mass well. The pot is moulded by hand upon a wooden block, supported on a spindle which turns in a hole in the bench; there is a gauge to regulate the thickness of the melting pot, and a cap of linen or cotton placed wet upon the core before the clay is applied, to prevent the clay from sticking partially to the core, in the taking off; the cap adheres to the pot only while wet, and may be removed without trouble or hazard when dry. He employs a wooden bat to assist in moulding the pot; when moulded, it is carefully dried at a gentle heat. A pot dried as above, when wanted for use, is first warmed by the fire-side, and is then laid in the furnace with the mouth downwards (the red cokes being previously damped with cold ones in order to lessen the heat); more coke is then thrown in till the pot is covered, and it is now brought up gradually to a red heat. The pot is next turned and fixed in a proper position in the furnace, without being allowed to cool, and is then charged with cold iron, so that the metal, when melted, shall have its surface a little below the mouth of the pot. The iron is melted in about an hour and a half, and no flux or addition of any kind is made use of. A pot will last for fourteen or even eighteen successive meltings, provided it is not allowed to cool in the intervals; but if it cool, it will probably crack. These pots, it is said, can bear a greater heat than others without softening, and will, consequently, deliver the metal in a more fluid state than the best Birmingham pots will. See a figure of the crucible mould under STEEL.

CRYSTAL is the geometrical form possessed by a vast number of mineral and saline substances; as also by many vegetable and animal products. The integrant particles of matter have undoubtedly determinate forms, and combine with one another, by the attraction of cohesion, according to certain laws, and points of polarity, whereby they assume a vast variety of secondary crystalline forms. The investigation of these laws belongs to crystallography, and is foreign to the practical purpose of this volume. Instructions are given under each object of manufacture which requires crystallization, how to conduct this process; see BORAX, SALT, &c.

CUDBEAR was first made an article of trade in this country, by Dr. Cuthbert Gordon, from whom it derived its name, and was originally manufactured on a great scale by Mr. G. Mackintosh at Glasgow, nearly 60 years ago. Cudbear or persio is a

* This crucible had been analyzed before being baked in the kiln.

olet red color, difficult to moisten with water, and of a peculiar but not
lor.   It is partially soluble in boiling water, becomes red with acids, and
h alkalis.   It is prepared in the same way as archil, only towards the
nce is dried in the air, and is then ground to a fine powder, taking care to
sition, which renders it glutinous. In Scotland they use the lichen tar-
arely the lichen calcareus, and omphalodes; most of which lichens are
Sweden and Norway, under the name of rock moss. The lichen is suffered
a month, and is then stirred about to allow any stones which may be pre-
:he bottom.   The red mass is next poured into a flat vessel, and left to
its urinous smell has disappeared, and till it has assumed an agreeable
ipon violet.   It is then ground to fine powder. During the fermentation
it is watered with stale urine, or with an equivalent ammoniacal liquor of
 making archil.
[ION is a mode of analyzing gold, silver, palladium, and platinum, by
ll portions of alloys, containing these metals, a bit of lead, fusing the
ttle cup of bone earth called a cupel, then by the joint action of heat and
the copper, tin, &c., present in the precious metals. The oxydes thus pro-
olved and carried down into the porous cupel in a liquid state, by the
of lead. See ASSAY, GOLD, and SILVER.
} OF LEATHER (Corroyer, Fr.; Zurichten, Germ.) is the art of
after they are tanned, for the purpose of the shoe-maker, coach and harness
· of giving them the necessary smoothness, lustre, color, and suppleness.
ihop has no resemblance to the tanner's premises, having a quite different
d manipulations.
employs a strong hurdle about a yard square, made either of basket twigs,
spars, fixed rectangularly like trellis work, with holes 3 inches square,
: treads the leather, or beats it with a mallet or hammer, in order to soften
it flexible.
ife, called in French couteau à revers, on account of the form of its edge,
h turned over, is a tool 5 or 6 inches broad, and 15 or 16 long; with
ine in the direction of the blade, and the other perpendicular to it, for the

purpose of guiding the
edge more truly upon
the skin. The pommel
(paumelle) is so called
because it clothes the
palm of the hand, and
performs its functions.
It is made of hard wood,
and is of a rectangular
shape, 1 foot long, 5
inches broad, flat above
and rounded below. It is
furrowed over the round-
ed surface with transverse
parallel straight grooves.
These grooves are in
section sharp-edged isos-
celes triangles. Figs.
354 and 355, repre-
sent the pommel in an
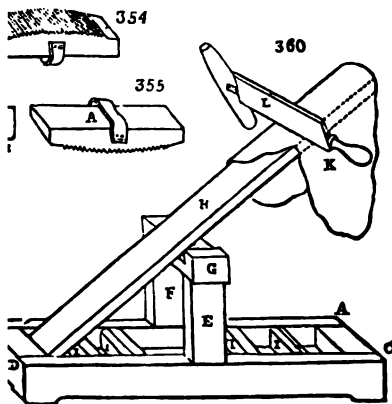
ider view. The flat surface is provided with a leather strap for secur-
: hand of the workman. Pommels are made of different sizes, and
of various degrees of fineness.   Cork pommels are also used, but they
:d.   Pommels serve to give grain and pliancy to the skins.
ing iron, fig. 356, is a flat plate of iron or copper, fully a fourth of an
top, and thinning off at bottom in a blunt edge, shaped like the arc of a
: diameter, having the angles a and b rounded, lest in working they should
leather.   The top c is mounted with leather to prevent it from hurting the
pper stretching knife is used for delicate skins.   The workman holds this
rpendicular, and scrapes the thick places powerfully with his two hands,
se where some tan or flesh remains.   He thus equalizes the thickness of
renders it at the same time more dense and uniform in texture. This tool
:ral use in currying.
knife, figs. 357 and 358 (lunette in French), is a circular knife from 10 to
liameter, with a round 4 or 5 inch hole in its centre, for introducing the
rking it.   It is concave, as shown in the section fig. 358, presenting the

form of a spherical zone. The concave part is that applied to the skin. Its edge is not perfectly straight; but is a little turned over on the side opposite to the skin, to prevent it from entering too far into the leather. The currier first slopes off with the head knife from the edges, a portion equal to what he afterwards removes with the round one. By this division the work is done sooner and more exactly. All the oiled or greased skins are dressed with the round knife.
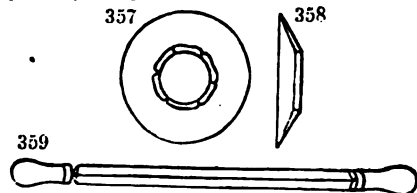
357   358   359

The *cleaner* is a straight two-handled knife two inches broad, of which there are two kinds, a sharp-edged and a blunt one. *Fig.* 359.

The *mace* is made of wood, having a handle 30 inches long, with a cubical head or mallet; upon the two faces of which, parallel to the line of the handle, there are 4 pegs of hard wood turned of an egg-shape, and well polished, so as not to tear the moistened leather when it is strongly beat and softened with the mace.

The horse or trestle, *fig.* 360, consists of a strong wooden frame, A B C D, which serves as a leg or foot. Upon the middle of this frame there are two uprights, E F, and a strong cross beam, G, for supporting the thick plank H, upon which the skins are worked. This plank may be set at a greater or less slope, according as its lower end is engaged in one or other of the cross bars, I I I I, of the frame. In the figure, a skin K is represented upon the plank with the head knife upon it, in the act of being pared.

A cylindrical bar fixed horizontally at its ends to two buttresses projecting from the wall, serves by means of a parallel stretched cord, to fix a skin by a coil or two in order to dress it. This is accordingly called the *dresser*. The tallow cloth is merely a mop made of stout rags, without the long handle; of which there are several, one for wax, another for oil, &c. Strong-toothed pincers with hook-end handles, drawn together by an endless cord, are employed to stretch the leather in any direction, while it is being dressed. The currier uses clamps like the letter U, to fix the edges of the leather to his table. His polisher is a round piece of hard wood, slightly convex below, with a handle standing upright in its upper surface, for seizing it firmly. He first rubs with sour beer, and finishes with barberry juice.

Every kind of tanned leather not intended for soles or such coarse purposes, is generally curried before being delivered to the workmen who fashion it, such as shoemakers, coachmakers, saddlers, &c. The chief operations of the currier are four:—

1. Dipping the leather, which consists in moistening it with water, and beating it with the *mace* or a mallet upon the hurdle. He next applies the *cleaners*, both blunt and sharp, as well as the head knife, to remove or thin down all inequalities. After the leather is shaved, it is thrown once more into water, and well scoured by rubbing the grain side with pumice stone, or a piece of slaty grit, whereby it parts with the bloom, a whitish matter, derived from the oak bark in the tan pit.

2. Applying the pommel to give the leather a granular appearance, and correspondent flexibility. The leather is first folded with its grain side in contact, and rubbed strongly with the pommel, then rubbed simply upon its grain side; whereby it becomes extremely flexible.

3. Scraping the leather. This makes it of uniform thickness. The workman holds the tool nearly perpendicular upon the leather, and forcibly scrapes the thick places with both his hands.

4. Dressing it by the round knife. For this purpose he stretches the leather upon the wooden cylinder, lays hold of the pendent under edge with the pincers attached to his girdle, and then with both hands applies the edge of the knife to the surface of the leather, slantingly from above downwards, and thus pares off the coarser fleshy parts of the skin. This operation requires great experience and dexterity; and when well performed improves greatly the look of the leather.

The hide or skin, being rendered flexible and uniform, is conveyed to the shed or drying house, where the greasy substances are applied, which is called dubbing (daubing) or stuffing. The oil used for this purpose is prepared by boiling sheep-skins or doe-skins, in cod oil. This application of grease is often made before the graining board or pommel is employed.

Before waxing, the leather is commonly colored by rubbing it with a brush dipped into a composition of oil and lamp black on the flesh side, till it be thoroughly black; it is then black-sized with a brush or sponge, dried, tallowed with the proper cloth, and slicked upon the flesh with a broad smooth lump of glass; sized again with a sponge; and when dry, again curried as above described.

Currying leather on the hair or grain side, termed black on the grain, is the same in the first operation with that dressed on the flesh, till it is scoured. Then the first black

plied to it while wet, by a solution of copperas put upon the grain, after this has
rubbed with a stone; a brush dipped in stale urine is next rubbed on, then an iron
er is used to make the grain come out as fine as possible. It is now stuffed with
When dry, it is seasoned; that is, rubbed over with a brush dipped in copperas
r, on the grain, till it be perfectly black. It is next slicked with a good grit-stone,
ke out the wrinkles, and smooth the coarse grain. The grain is finally raised with
pommel or graining board, by applying it to the leather in different directions.
n thoroughly dry, it is grained again in two or three ways.
des intended for covering coaches are shaved nearly as thin as shoe hides, and
ted upon the grain.
JTLERY. (*Coutellerie*, Fr.; *Messerschmidwaare*, Germ.) Three kinds of steel
nade use of in the manufacture of different articles of cutlery, viz., common steel,
r steel, and cast steel. Shear steel is exceedingly plastic and tough. All the edge
which require great tenacity without great hardness are made of it, such as table
es, scythes, plane-irons, &c.
st steel is formed by melting blistered steel in covered crucibles, with bottle glass,
ouring it into cast-iron moulds, so as to form it into ingots; these ingots are then
n to the tilt, and drawn into rods of suitable dimensions. No other than cast steel
ussume a very fine polish, and hence all the finer articles of cutlery are made of it,
as the best scissors, penknives, razors, &c.
rmerly cast steel could be worked only at a very low heat; it can now be made so
be welded to iron with the greatest ease. Its use is consequently extended to
ng very superior kinds of chisels, plane-irons, &c.
rging of table knives. — Two men are generally employed in the forging of table
s; one called the foreman or maker, and the other the striker.
e steel called common steel is employed in making the very common articles; but
ne greatest part of table knives which require a surface free from flaws, shear steel
nerally preferred. That part of the knife termed the blade, is first rudely formed
ut off. It is next welded to a rod of iron about ¼ inch square, in such a manner
leave as little of the iron part of the blade exposed as possible. A sufficient quantity
e iron now attached to the blade, is taken off from the rod to form the bolster or
der, and the tang.
order to make the bolster of a given size, and to give it at the same time shape
neatness, it is introduced into a die, and a swage placed upon it; the swage has a
smart blows given it by the striker. This die and swage are, by the workman,
l prints.
ter the tangs and bolster are finished, the blade is heated a second time, and the
an gives it its proper anvil finish; this operation is termed smithing. The blade
v heated red-hot, and plunged perpendicularly into cold water. By this means it
nes hardened. It requires to be tempered regularly down to a blue color: in which
it is ready for the grinder.
. Brownill's method of securing the handles upon table-knives and forks, is, by
nening the tangs, so as to pass them completely through the handle, the ends of
n are to be tinned after the ordinary mode of tinning iron; and, when passed
gh the handle, the end of the tang is to be spread by beating, or a small hole
! through it, and a pin passed to hold it upon the handle. After this, caps of
, either copper plated or silver, are to be soldered on to the projecting end of the
and while the solder is in a fluid state, the cap is to be pressed upon the end of
andle and held there until the solder is fixed, when the whole is to be cooled by
immersed in cold water.
. Thomason's patent improvements consist in the adaptation of steel edges to the
s of gold and silver knives. These steel edges are to be attached to the other
, of whatever quality it may be, of which the knife, &c. is made, by means of
; in the ordinary mode of effecting that process. After the edge of steel is thus
ned to the gold, silver, &c., it is to be ground, polished, and tempered by immersion
d water or oil after being heated. This process being finished, the other parts of
aife are then wrought and ornamented by the engraver or chaser, as usual.
patent was obtained in 1827, by Mr. Smith of Sheffield, for rolling out knives at one
tion.
the ordinary mode of making knives, a sheet of steel being provided, the blades are
ut of the sheet, and the backs, shoulders, and tangs, of wrought iron, are attached to
eel blades by welding at the forge. The knife is then ground to the proper shape,
te blade polished and hardened.
tead of this welding process, the patentee proposes to make the knives entirely of
and to form them by rolling in a heated state between massive rollers; the shoul-
or bolsters, and the tangs for the handles, being produced by suitable recesses in
eripheries of the rollers; just as rail-way rails are formed. When the knife is to

be made with what is called a scale tang, that is, a broad flat tang, to which the handle is to be attached in two pieces, riveted on the sides of the tang, the rollers are then only to have recesses cut in them, in a direction parallel to the axis for forming the bolster.

The plate of steel, having been heated, is to be pressed between the two rollers, by which the blades and the parts for the scale tangs will be pressed out flat and thin, and those parts which pass between the grooves or recess will be left thick or protuberant, forming the bolster for the shoulder of the blade. But if the tangs are to be round in order to be fixed into single handles, then it will be necessary also to form transverse grooves in the rollers, that is, at right angles to those which give shape to the bolsters, the transverse grooves corresponding in length to the length of the intended tang. When the plates of steel have been thus rolled, forming three or more knives in a breadth, the several knives are to be cut out by the ordinary mode of what is called slitting, and the blades and shoulders ground, hardened, and polished in the usual way.

Forks are generally a distinct branch of manufacture from that of knives, and are purchased of the fork makers by the manufacturers of table knives, in a state fit for receiving the handles.

The rods of steel from which the forks are made, are about ⅞ths of an inch square. The tang and shank of the fork are first roughly formed. The fork is then cut off, leaving at one end about 1 inch of the square part of the steel. This part is afterwards drawn out flat to about the length of the prongs. The shank and tang are now heated, and a proper form given to them by means of a die and swage. The prongs are afterwards formed at one blow by means of the stamp; this machine is very similar to that used in driving piles. but it is worked by one man. It consists of a large anvil fixed in a block of stone nearly on a level with the ground. To this anvil are attached two rods of iron of considerable thickness, fixed twelve inches asunder, perpendicularly to the anvil, and diagonally to each other. These are fastened to the ceiling. The hammer or stamp, about 100 lbs. in weight, having a groove upon either side corresponding to the angles of the upright rods, is made to slide freely through its limited range, being conducted by its two iron supporters. A rope is attached to the hammer, which goes over a pulley on the floor of the room above, and comes down to the person who works the stamp: two corresponding dies are attached, one to the hammer, and the other to the anvil. That part of the fork intended to form the prongs, is heated to a pretty white heat and placed in the lower die, and the hammer containing the other die is made to fall upon it from a height of about 7 or 8 feet. This forms the prongs and the middle part of the fork, leaving a very thin substance of steel between each prong, which is afterwards cut out with an appropriate instrument called a fly-press. The forks are now annealed by surrounding a large mass of them with hot coals, so that the whole shall become red-hot. The fire is suffered gradually to die out, and the forks to cool without being disturbed. This process is intended to soften, and by that means to prepare them for filing. The inside of the prongs is then filed, after which they are bent into their proper form and hardened. When hardened, which is effected by heating them red-hot and plunging them into cold water, they are tempered by exposing them to the degree of heat at which grease inflames. See STAMPS.

Penknives are generally forged by a single hand, with the hammer and the anvil simply. The hammer in this trade is generally light, not exceeding 3½ lbs. The breadth of the face, or the striking part, is about one inch; if broader, it would not be convenient for striking so small an object. The principal anvil is about 5 inches, and 10 upon the face, and is provided with a groove into which a smaller anvil is wedged. The smaller anvil is about 2 inches square upon the face. The blade of the knife is first drawn out at the end of the rod of steel, and as much more is cut off along with it as is thought necessary to form the joint. The blade is then taken in a pair of tongs, and heated a second time to finish the joint part, and at the same time to form a temporary tang for the purpose of driving into a small haft used by the grinder. Another heat is taken to give the blade a proper finish. The small recess called the nail-hole, used in opening the knife, is made while it is still hot by means of a chisel, which is round on one side, and flat upon the other.

Penknives are hardened by heating the blade red-hot, and dipping them into water up to the shoulder. They are tempered by setting them side by side, with the back downwards upon a flat iron plate laid upon the fire, where they are allowed to remain till they are of a brown or purple color.

The blades of pocket knives, and all that come under the denomination of spring knives, are made in the same way.

The forging of razors is performed by a foreman and striker, as in making table knives.

They are generally made of cast steel. The rods, as they come from the tilt, are about ½ inch broad, and of a thickness sufficient for the back of the razor.

There is nothing peculiar in the tools made use of in forging razors: the anvil is a

at the sides, which affords the opportunity of making the edge thinner, and
nse labor to the grinder.

hardened and tempered in a similar manner to penknives. They are,
harder, being only let down to yellow or brown color.

of scissors is wholly performed by the hammer, and all the sizes are made
ind. The anvil of the scissor-maker weighs about 1½ cwt.; it measures,
ont 4 by 11 inches. It is provided with two grates or grooves for the re-
rious little indented tools termed by the workman bosses; one of these
oyed to give proper figure to the shank of the scissors; another for form-
vhich has to make the joint; and a third is made use of for giving a proper
upper side of the blade. There is also another anvil placed on the same
ing two or three tools called beak-irons, each consisting of an upright stem
s high, at the top of which a horizontal beak projects; one of these beaks
. is used for extending the bow of the scissors; the other is a segment of a
the round side upwards, containing a recess for giving a proper shape and
the inside of the bow.

of the scissors is first formed by means of one of the bosses, above de-
g as much steel at the end as will form the blade. A hole is then punched
n width, a little above the shank. The blade is drawn out and finished,
rs separated from the rod a little above the hole. It is heated a third time,
hole above mentioned is extended upon the beak-irons so as to form the
nishes the forging of scissors. They are promiscuously made in this way,
ther guide than the eye, having no regard to their being in pairs. They
aled for the purpose of filing such parts of them as cannot be ground, and
ired.

.rge scissors are made partly of iron, the blades being of steel.

forging, the bow and joints, and such shanks as cannot be ground, are
vet hole is then bored, through which they are to be screwed or riveted
.is common kind of scissors is only hardened up to the joint. They
down to a purple or blue color. In this state they are taken to the

nd polishing of cutlery.—The various processes which come under this
are performed by machinery, moving in general by the power of the steam-
er-wheel.

heels or grinding mills are divided into a number of separate rooms; every
. six places called troughs; each trough consists of a convenience for run-
one and a polisher at the same time, which is generally occupied by a man

ss of the grinder is generally divided into three stages, viz., grinding,
polishing.

ig is performed upon stones of various qualities and sizes, depending on the
ground. Those exposing much flat surface, such as saws, fenders, &c.,
s of great diameter, while razors, whose surface is concave, require to be
stones of very small dimensions. Those articles which require a certain
1 is the case with most cutting instruments, are mostly ground on a wet
tich purpose the stone hangs within the iron trough, filled with water to
that its surface may just touch the face of the stone.

a process following that of grinding: it consists in giving that degree of
noothness to an article which can be effected by means of emery of the
es of fineness. The tool on which the glazing is performed, is termed a
nsists of a circular piece of wood, formed of a number of pieces in such a
its edge or face may always present the endway of the wood. Were it
ise, the contraction of the parts would destroy its circular figure. It is
. iron axis similar to that of the stone. Some glazers are covered on the
ther, others with metal, consisting of an alloy of lead and tin; the latter
ps. In others, the wooden surface above is made use of. Some of the
glazers, such as are used for forks, table knives, edge tools, and all the
ied articles, are first coated with a solution of glue, and then covered with
surfaces of the others are prepared for use by first turning the face very
ing it with small notches by means of a sharp-ended hammer, and lastly
interstices with a compound of tallow and emery.

of the glazer is so much less than that of the stone, that its velocity is
ible, having in general a surface speed of 1500 feet in a second.

s of polishing consists in giving the most perfect polish to the different
hing is subjected to this operation but what is made of cast steel, and has
ly hardened and tempered.

r consists of a circular piece of wood covered with buff leather, the surface

of which is covered from time to time, while in use, with the crocus of iron, called also colcothar of vitriol.

The polisher requires to run at a speed much short of that of the stone, or the glazer. Whatever may be its diameter, the surface must not move at a rate exceeding 70 or 80 feet in a second.

CYANATES; saline compounds of cyanic acid with the bases potash, soda, ammonia, baryta, &c. The first is prepared by calcining, at a dull red heat, a mixture of ferro-cyanide of potassium (prussiate of potash) and black oxyde of manganese. The cyanates have not hitherto been applied to any use in the arts.

CYANHYDRIC Acid; another name for the hydrocyanic or prussic acid. See PRUS-SIAN BLUE and PRUSSIC ACID.

CYANIDES; compounds of cyanogen with the metals; as cyanide of potassium, sodium, barium, calcium, iron, mercury. The last is the only one of importance in a manufacturing point of view, since from it prussic acid is made.

CYANIDES, FERRO. Double compounds of cyanogen with iron, and of cyanogen with another metal, such as potassium, sodium, barium, &c. The ordinary yellow prus-siate of potash has this constitution, and is called the ferro-cyanide.

CYANOGEN. A gaseous compound of two prime equivalents of charcoal = 12, and one of azote = 14 = 26; hydrogen being the radix, or 1. It consists of two volumes of vapor of carbon, and one volume of azote, condensed into one volume; and has there-fore a density equal to the sum of the weights of these three gaseous volumes = 1·815. Cyanogen is readily procured by exposing the cyanide of mercury to a dull red heat in a retort; the gas is evolved and may be collected over mercury. Its smell is very sharp and penetrating: it perceptibly reddens tincture of litmus; it is condensable by pressure at a low temperature into a liquid; and by a still greater degree of cold, it is solidified. When a lighted taper is applied to a mixture of cyanogen and oxygen, an explosion takes place; carbonic acid is formed, and the azote is set at liberty.

For a connected view of the various compounds of cyanogen employed in the arts, see PRUSSIAN BLUE.

CIDER (Cidre, Fr.; Äpfelwein, Germ.); the vinous fermented juice of the apple. The ancients were acquainted with cider and perry, as we learn from the following pas-sage of Pliny the naturalist: "Wine is made from the Syrian pod, from pears and apples of every kind." Book xiv. chap. 19. The term cider or cidre in French, at first written sidre, is derived from the Latin word sicera, which denoted all other fermented liquors except grape wine. Cider seems to have been brought into Normandy by the Moors of Biscay, who had preserved the use of it after coming into that country from Africa. It was afterwards spread through some other provinces of France, whence it was intro-duced into England, Germany, and Russia. It is supposed that the first growths of Nor-mandy afford still the best specimens of cider. Devonshire and Herefordshire are the counties of England most famous for this beverage.

Strong and somewhat elevated ground, rather dry, and not exposed to the air of the sea, or to high winds, are the best situations for the growth of the cider apple. The fruit should be gathered in dry weather. The juice of apples is composed of a great deal of water; a little sugar analogous to that of the grape; a matter capable of causing fermentation with contact of air; a pretty large proportion of mucilage, with malic acid, acetic acid, and an azotized matter in a very small quantity. The seeds contain a bitter substance and a little essential oil; the pure parenchyma or cellular membrane constitutes not more than two per cent. of the whole. After the apples are gathered, they are left in the barn-loft for fifteen days or upwards to mellow; some of them in this case, how-ever, become soft and brown. This degree of maturation diminishes their mucilage, and develops alcohol and carbonic acid; in consequence of which the cider suffers no injury. There is always, however, a little loss; and if this ripening goes a little further it is very apt to do harm, notwithstanding the vulgar prejudice of the country people to the contrary. Too much care, indeed, cannot be taken to separate the sound from the spoiled apples; for the latter merely furnish an acid leaven, give a disagreeable taste to the juice, and hinder the cider from fining, by leaving in it a certain portion of the parenchyma, which the gelatinous matter or the fermentation has diffused through it. Unripe apples should be separated from the ripe also, for they possess too little saccha-rum to be properly susceptible of the vinous fermentation.

In France, where cider making is most scientifically practised, it is prepared by crushing the apples in a mill with revolving edge-stones, turned in a circular stone cis-tern by one or two horses. When the fruit is half mashed, about one fifth of its weight of river water is added, or the water of lakes. The latter have been found by expe-rience to be preferable to other water.

In some places a mill composed of two cast-iron fluted cylinders placed parallel to each other under the bottom of a hopper, is employed for crushing the apples. One of the cylinders is turned by a winch, and communicates its motion in the opposite direc-

of the flutings working into each other.   Each portion of the fruit must
ce through this rude mill in order to be sufficiently mashed; and the same
ater must be added as in the edge stone mill.
iples are crushed they are usually put into a large tub or tun for 12 or 24
steeping aids the separation of the juice, because the fermentative motion
lace in the mass breaks down the cellular membranes; but there is always
hol carried off by the carbonic acid disengaged, while the skins and seeds
greeable taste in the liquid.   The vatting might be suppressed if the apples
iinuted as to give out their juice more readily.   With slight modifications,
mployed in rasping and squeezing the beet-roots might in my opinion be
rreat advantage to the cider manufacture.   See SUGAR.
atting, the mashed fruit is carried to the press and put upon a square wicker
a hair bag, sometimes between layers of straw, and exposed stratum super
rong pressure till what is called a cheese or cake is formed.   The mass
wed to drain for some time before applying pressure, which ought to
lually increased.   The juice which exudes with the least pressure
st cider; that which flows towards the end acquires a disagreeable taste
s and the skins.   The must is put into casks with large bungholes, where
s to exhibit a tumultuous fermentation.   The cask must be completely
r that all the light bodies suspended in the liquid when floated to the top
nic acid may flow over with the froth; this means of clearing cider is
iecessary with the weak kinds, because it cannot be expected that these
spension will fall to the bottom of the casks after the motion has ceased.
ry circumstance besides, when no saccharine matter has been added to the
id of yeast which rises to the top must be separated, lest by precipitation
an acid fermentation in the cider.   The casks are raised upon gawntrees
i order to place flat tubs below them to receive the liquor which flows over
h.   At the end of two or three days, for weak ciders which are to be
hat sweet, of 6 or 10 days or more for stronger ciders, with variations for
ie weather, the fermentation will be sufficiently advanced, and the cider may
into other casks.   Spirit puncheons preserve cider better than any other,
es the casks should be well seasoned and washed.   Sometimes a sulphur
ned in them before introducing the cider, a precaution to be generally
, as it suspends the activity of the fermentation, and prevents the formation

procured by the first expression is called cider without water.   The cake
the press is taken out, divided into small pieces, and mashed anew, adding
e weight of water, when the whole is carried back to the press and treated
ribed.   The liquor thus obtained furnishes a weaker cider which will not
refore must be drunk soon.
is once more mashed up with water, and squeezed, when it yields a liquor
e used instead of water for moistening fresh ground apples.
sses above described, although they have been long practised, and have
stamp of ancestral wisdom, are extremely defective.   Were the apples ground
r rotatory rasp which would tear all their cells asunder, and the mash put
iydraulic press in bags between hurdles of wicker-work, the juice would
in a state of perfection fit to make a cider superior to many wines.
ntal process of this kind has been actually executed in France upon a con-
le, with the best results.   The juice had the fine flavor of the apple, was
itself without any previous fermentation in the mash, and afforded an excel-
der which kept well.
must of the apples is weak or sour, good cider cannot be made from it
iddition of some saccharine matter.   The sirup into which potato farina
: by *diastase* (saccharine ferment), see STARCH and SUGAR, would answer
:hing poor apple juice.

D.

2, the same as Inuline, the fecula obtained from elecampane, analogous in
s to starch.   It is not employed in the arts.
US BLADES, are swords or cimeters, presenting upon their surface
appearance of *watering*, as white, silvery, or black veins, in fine lines,
rous, crossed, interlaced, or parallel, &c.   They are brought from the East,
ted chiefly at Damascus, whence their name.   Their excellent quality has
erbial; for which reason these blades are much sought after by military

men, and are high priced. The oriental processes have never been satisfactorily de-
scribed; but of late years methods have been devised in Europe to imitate the fabric very
well.

Clouet and Hachette pointed out the three following processes for producing Da-
mascus blades : 1, that of *parallel fillets*; 2, that by *torsion*; 3, the *mosaic*. The first,
which is still pursued by some French cutlers, consists in scooping out with a graving
tool the faces of a piece of stuff composed of thin plates of different kinds of steel.
These hollows are by a subsequent operation filled up, and brought to a level with the
external faces, upon which they subsequently form tress-like figures. 2. The method of
torsion which is more generally employed at present, consists in forming a bundle of
rods or slips of steel, which are welded together into a well-wrought bar, twisted
several times round its axis. It is repeatedly forged, and twisted alternately; after
which it is slit in the line of its axis, and the two halves are welded with their outsides
in contact; by which means their faces will exhibit very various configurations. 3. The
mosaic method consists in preparing a bar, as by the torsion plan, and cutting this bar
into short pieces of nearly equal length, with which a fagot is formed and welded
together; taking care to preserve the sections of each piece at the surface of the blade.
In this way, all the variety of the design is displayed, corresponding to each fragment of
the cut bar.

The blades of Clouet, independently of their excellent quality, their flexibility, and
extreme elasticity, have this advantage over the oriental blades, that they exhibit in the
very substance of the metal, designs, letters, inscriptions, and, generally speaking, all
kinds of figures which had been delineated beforehand.

Notwithstanding these successful results of Clouet, it was pretty clear that the watered
designs of the true Damascus cimeter were essentially different. M. Bréant has at
last completely solved this problem. He has demonstrated that the substance of the
oriental blades is a cast-steel more highly charged with carbon than our European steels,
and in which, by means of a cooling suitably conducted, a crystallization takes place
of two distinct combinations of carbon and iron. This separation is the essential condi-
tion; for if the melted steel be suddenly cooled in a small crucible or ingot, there is no
damascene appearance.

If an excess of carbon be mixed with iron, the whole of the metal will be converted
into steel; and the residuary carbon will combine in a new proportion with a portion of
the steel so formed. There will be two distinct compounds; namely, pure steel, and
carbureted steel or cast-iron. These at first being imperfectly mixed will tend to
separate, if while still fluid they be left in a state of repose; and form a crystallization
in which the particles of the two compounds will place themselves in the crucible in an
order determined by their affinity and density conjoined. If a blade forged out of steel
so prepared be immersed in acidulous water, it will display a very distinct Damascus
appearance; the portions of pure steel becoming black, and those of carbureted steel
remaining white, because the acids with difficulty disengage its carbon. The slower
such a compound is cooled, the larger the Damascus veins will be. Travernier relates
that the steel crucible ingots, like those of wootz, for making the true oriental Damascus,
come from Golconda, that they are of the size of a halfpenny roll, and when cut in two,
form two swords.

Steel combined with manganese forges easily, but it is brittle when cold; it displays
however the Damascus appearance very strongly.

A mixture of 100 parts of soft iron, and 2 of lamp black, melts as readily as ordinary
steel. Several of the best blades which M. Bréant presented to the Société d'Encourage-
ment are the product of this combination. This is an easy way of making cast-steel
without previous cementation of the iron. 100 parts of filings of very gray cast-iron, and
100 parts of like filings previously oxydized, produced, by their fusion together, a beautiful
damascene steel, fit for forging into white arms, sabres, swords, &c. This compound is
remarkable for its elasticity, an essenial quality, not possessed by the old Indian steel.
The greater the proportion of the oxydized cast-iron, the tougher is the steel. Care should
be taken to stir the materials during their fusion, before it is allowed to cool; otherwise
they will not afford a homogeneous damasc. If the steel contains much carbon it
is difficult to forge, and cannot be drawn out except within a narrow range of temperature.
When heated to a red-white it crumbles under the hammer; at a cherry-red it becomes
hard and brittle; and as it progressively cools it becomes still more unmalleable. It re-
sembles completely Indian steel, which European blacksmiths cannot forge, because they
are ignorant of the suitable temperature for working it. M. Bréant, by studying this
point, succeeded in forging fine blades.

Experience has proved that the orbicular veins, called by the workmen *knots* or
thorns (*ronces*), which are seen upon the finest Eastern cimeters, are the result of the
manner of forging them, as well as the method of twisting the Damascus bars. If
these be drawn in length, the veins will be longitudinal; if they be spread equally in all

directions, the stuff will have a crystalline aspect; if they be made wavy in the two directions, undulated veins will be produced like those in the oriental Damascus.

DAMASK is a variegated textile fabric, richly ornamented with figures of flowers, fruits, landscapes, animals, &c., woven in the loom, and is by far the most rich, elegant, and expensive species of ornamental weaving, tapestry alone excepted. The name is said to be derived from Damascus, where it was anciently made.

Damask belongs to that species of texture which is distinguished by practical men by the name of tweeling, of which it is the richest pattern. The tweel of damask is usually half that of full *satin*, and consequently consists of eight leaves moved either in regular succession or by regular intervals, eight leaves being the smallest number which will admit of alternate tweeling at equal intervals.

In the article CARPET, two representations have been given of the damask drawloom.

The generic difference of tweeling, when compared with common cloth, consists in the intersections, although uniform and equidistant, being at determinate intervals, and not between the alternate threads. Hence we have specimens of tweeled cloth, where the intersections take place at the third, fourth, fifth, sixth, seventh, eighth, or sixteenth interval only. The threads thus deflecting only from a straight line at intervals, preserve more of their original direction, and a much greater quantity of materials can be combined in an equal space, than in the alternate intersection, where the tortuous deflection, at every interval, keeps them more asunder. On this principle tweeled cloths of three and four leaves are woven for facility of combination alone. The coarser species of ornamented cloths, known by the names of dornock and diaper, usually intersect at the fifth, or half satin interval. The sixth and seventh are rarely used, and the intersection at the eighth is distinguished by the name of satin in common, and of damask in ornamental tweeling. It will further be very obvious, that where the warp and woof cross only at every eighth interval, the two sides of the cloth will present a diversity of appearance; for on one side the longitudinal or warp threads will run parallel from one end of a web to the other, and, on the other, the threads of woof will run also parallel, but in a transverse direction across the cloth, or at right angles to the former. The points of intersection being only at every eighth interval, appear only like points; and in regular tweeling these form the appearance of diagonal lines, inclined at an angle of 45° (or nearly so) to each of the former.

The appearance, therefore, of a piece of common tweeled cloth is very similar to that of two thin boards glued together, with the grain of the upper piece at right angles to that of the under one. That of an ornamental piece of damask may, in the same manner, be very properly assimilated to a piece of veneering, where all the wood is of the same substance and color, and where the figures assume a diversity of appearance from the ground, merely by the grain of the one being disposed perpendicularly to that of the other. See TEXTILE FABRIC.

From this statement of the principle, it results that the most unlimited variety of figures will be produced, by constructing a loom by which every individual thread of warp may be placed either above or below the woof at every intersection; and to effect this, in boundless variety, is the object of the Jacquard mounting; which see.

The chief seat of this manufacture is probably the town and neighborhood of Dunfermline, in Fifeshire, and Lisburn and Ardoyne, near Belfast, where it is considered as the staple, having proved a very profitable branch of traffic to the manufacturer, and given employment to many industrious people.

The material used there is chiefly linen; but many have been recently woven of cotton, since the introduction of that article into the manufacture of cloth has become so prevalent. The cotton damasks are considerably cheaper than those of linen; but are not considered either so elegant or durable. The cotton, also, unless frequently bleached, does not preserve the purity of the white color nearly so well as the linen.

DAMASKEENING; the art of ornamenting iron, steel, &c., by making incisions upon its surface, and filling them up with gold or silver wire; chiefly used in enriching sword blades, guards, and gripes, locks of pistols, &c.

Its name shows the place of its origin, or, at least, the place where it has been practised in the greatest perfection; viz., the city of Damascus, in Syria; though M. Felibien attributes the perfection of the art to his countryman, Cursinet, who wrought under the reign of Henry IV.

Damaskeening is partly mosaic work, partly engraving, and partly carving. As mosaic work it consists of pieces inlaid; as engraving, the metal is indented, or cut in intaglio; and as carving, gold and silver are wrought into it in *relievo*.

There are two ways of damaskeening; in the first, which is the most beautiful, the artists cut into the metal with a graver, and other tools proper for engraving upon steel, and afterwards fill up the incisions, or notches, with a pretty thick silver or gold wire. In the other, which is only superficial, they content themselves to make hatches,

or strokes across the iron, &c. with a cutting knife, such as is used in making of small files. As to the first, it is necessary for the gravings or incisions to be made in the dovetail form; that the gold or silver wire, which is thrust forcibly into them, may adhere the more strongly. As to the second, which is the more usual, the method is this :—Having heated the steel till it changes to a violet, or blue color, they hatch it over and across with the knife; then draw the ensign or ornament intended, upon this hatching, with a fine brass point or bodkin. This done, they take fine gold wire, and conducting or chasing it according to the figures already designed, they sink it carefully into the hatches of the metal with a copper tool.

DAMASSIN is a kind of damask, with gold and silver flowers, woven in the warp and woof; or occasionally with silk organzine.

DAMPS, in mining, are noxious exhalations, or rather gases, so called from the German *dampf*, vapor. There are two principal kinds of mine gases, the *fire-damp*, or carbureted hydrogen, and the *choke-damp*, or carbonic acid gas. See MINES.

DAPHNINE; the bitter principle of the *Daphne Alpina*.

DATOLITE. A mineral composed of silica, lime, and boracic acid.

DECANTATION (Eng. and Fr.; *Abgiessen*, Germ.) is the act of pouring off the clear supernatant fluid from any sediment or deposite. It is much employed in the chemical arts; and is most conveniently effected by a syphon.

DECOCTION (Eng. and Fr.; *Abkochung*, Germ.) means either the act of boiling a liquid along with some organic substance, or the liquid compound resulting from that act.

DECOMPOSITION (Eng. and Fr.; *Zersetzung*, Germ.) is the separation of the constituent principles of any compound body. The following table, the result of important researches recently made by M. Persoz, Professor of Chemistry at Strasburgh, shows the order in which decompositions take place among the successive substances.

Nitric Acid.	Muriatic Acid.
Oxyde of Magnesium	Oxyde of Magnesium
— Silver	— Cobalt
— Cobalt	— Nickel
— Nickel	Protox. of Mercury
Protox. of Cerium	— Cerium
Oxyde of Zinc	Oxyde of Zinc
Protox. of Manganese	Protox. of Manganese
Oxyde of Lead	— Iron
— Cadmium	— Uranium
— Copper	— Copper
— Glucinum	— Tin
— Aluminum	Oxyde of Glucinum
— Uranium	— Aluminum
— Chromium	— Uranium
Protox. of Mercury	— Chromium
Oxyde of Mercury	— Iron
— Iron	— Tin
— Bismuth	— Bismuth
	— Antimony

By means of the cupric oxyde we may separate, 1, the ferric oxyde from the manganous oxyde; 2, the cobaltic, nickelic, zincic and cerous oxydes from the uranic, ferric, chromic, and aluminic oxydes; 3, the ferrous oxyde from the chromic oxyde, when dissolved in the muriatic acid.

In boiling a muriatic solution of the cobaltic, nickelic, and manganous oxydes, with the mercuric oxyde, the first two oxydes alone are precipitated. Alumina separates the cadmic oxyde from the bismuthic oxyde, the stannous oxyde from the stannic oxyde, and the stannous oxyde from the antimonic acid. The cupric oxyde separates also by precipitation, the aluminic, uranic, chromic, titanic, and vanadic oxydes from all the oxydes which are precipitable in the state of sulphuret, by hydrosulphuret of ammonia.

As an example of this mode of analysis—

Dissolve pech-blende in aqua regia, precipitate its copper by sulphureted hydrogen, boil the liquid along with nitric acid, in order to transform all the uranium into uranic acid. Next boil it along with cupric oxyde, which precipitates only the uranic and ferric oxydes. Redissolve the precipitate in nitric acid, and boil the solution with mercuric oxyde, which does not precipitate the ferric oxyde. Finally, separate the copper and the mercury from the uranium, by means of sulphureted hydrogen. In this process we may substitute plumbic oxyde for the cupric oxyde, and succeed equally well.

Knowledge, like the above, of the elective affinities and habitudes of chemical bodies, simple and compound, imparts to its possessor an irresistible power over the unions and

unions of the elements, which he can exercise with certainty in effecting innumerable nsformations in the arts.

DECREPITATION (Eng. and Fr.; *Verknistern*, Germ.) is the crackling noise, ended with the flying asunder of their parts, made by several salts and minerals, en heated. It is caused by the unequal sudden expansion of their substance by the it. Sulphate of baryta, chloride of sodium, calcareous spar, nitrate of baryta, and many re bodies which contain no water, decrepitate most violently, separating at the natural ats of their crystalline structure. Some chemists have preposterously enough ascribed : phenomenon to the expansion of the combined water into steam. What a specimen inductive philosophy !

DEFECATION (Eng. and Fr.; *Klaren*, Germ.), the freeing from dregs or impurities.

DEFLAGRATION (Eng. and Fr.; *Verpuffung*, Germ.), the sudden blazing up of a nbustible; as of a charcoal or sulphur when thrown into melted nitre.

DELPHINIA. The vegeto-alkaline principle of the *Delphinium staphysagria*, or vesacre. It is poisonous.

DELIQUESCENT (*Zerfliessen*, Germ.) is said of a solid which attracts so much isture from the air as to become spontaneously soft or liquid; such as potash and riate of lime.

DEPHLEGMATION is the process by which liquids are deprived of their watery par- es. It is applied chiefly to spirituous liquors, and is now nearly obsolete, as involving alchemistical notion of a peculiar principle called phlegm.

DEPHLOGISTICATED; deprived of phlogiston, — formerly supposed to be the amon combustible principle. It is nearly synonymous with oxygenated. The idea ginally attached to the word having proceeded from false logic, the word itself should rer be used either in science or manufactures.

DEPILATORY (*Depilatoire*, Fr.; *Enthaarensmittel*, Germ.) is the name of any istance capable of removing hairs from the human skin without injuring its texture. ey act either mechanically or chemically. The first are commonly glutinous sters formed of pitch and rosin, which stick so closely to the part of the skin where y are applied, that when removed, they tear away the hairs with them. This method more painful, but less dangerous than the other, which consists in the solvent ion of a menstruum, so energetic as to penetrate the pores of the skin, and destroy bulbous roots of the hairs. This is composed either of caustic alkalis, sulphuret of yta, or arsenical preparations. Certain vegetable juices have also been recommended the same purpose; as spurge and acacia. The bruised eggs of ants have likewise n prescribed. But the *oriental rusma* yields to nothing in depilatory power. let de Gassincourt has published in the *Dictionnaire des Sciences Medicales*, the follow- recipe for preparing it.

Mix two ounces of quicklime with half an ounce of orpiment or realgar, (sulphuret arsenic;) boil that mixture in one pound of strong alkaline ley, then try its strength dipping a feather into it, and when the flue falls off, the *rusma* is quite strong enough. is applied to the human skin by a momentary friction, followed by washing with rm water. Such a caustic liquid should be used with the greatest circumspection, ;inning with it somewhat diluted. A soap is sometimes made with lard and the ive ingredients; or soft soap is combined with them; in either case to form a depila- r pommade. Occasionally one ounce of orpiment is taken to eight ounces of quicklime, two to twelve, or three to fifteen; the last mixture being of course the most active. causticity may be tempered by the addition of one eighth of starch or rye flour, so as form a soft paste, which being laid upon the hairy spot for a few minutes, usually car- s away the hairs with it.

The *rusma* should never be applied but to a small surface at a time, for independently the risk of corroding the skin, dangerous consequences might ensue from absorption the arsenic.

DETONATION. See FULMINATING, for the mode of preparing detonating powder for percussion caps of fire-arms.

DEUTOXYDE literally means the second oxyde, but is usually employed to denote ompound containing two atoms or two prime equivalents of oxygen to one or more of netal. Thus we say deutoxyde of copper, and deutoxyde of mercury. Berzelius has breviated this expression by adopting the principles of the French nomenclature of 37; according to which the higher stage of oxydizement is characterized by the termina- a *ic*, and the lower by *ous*, and he writes accordingly cupric and mercuric, to designate : deutoxydes of these two metals; cuprous and mercurous to designate their protoxydes. ave adopted this nomenclature in the article DECOMPOSITION, and in some other parts this Dictionary, as being short and sufficiently precise.

DEXTRINE is a matter of a gummy appearance into which the interior substance the molecules of starch is converted, through the influence of diastase or acids. It rives its name from the circumstance that it turns, more than any other body, the

plane of polarization to the right hand.   It is white, insipid, without smell, transparent in thin plates, friable, with a glassy fracture when well dried.   It is not altered by the heat of boiling water, but at 280° F. it becomes brown, and acquires the flavor of toasted bread.   It is not colored by iodine, like starch, it does not form muric acid with the nitric, as common gum does, and it is transformed into grape sugar, when heated along with dilute sulphuric acid or diastase.

Dextrine is much employed by the French pastry-cooks and confectioners ; it is a good substitute for gum arabic in medicine.   For the conversion of potato or other starch into dextrine by the action of diastase, see this article.

DIAMOND. Since this body is merely a condensed form of carbon, it cannot in a chemical classification be ranked among stones ; but as it forms in commerce the most precious of the gems, it claims our first attention in a practical treatise on the arts. Diamonds are distinguishable by a great many peculiar properties, very remarkable and easily recognised, both in their rough state, and when cut and polished.   Their most absolute and constant character is a degree of hardness superior to that of every mineral, whence diamonds scratch all other bodies, and are scratched by none.   Their peculiar adamantine lustre, not easy to define, but readily distinguishable by the eye from that of every other gem, is their most obvious feature.   Their specific gravity is 3·55.   Whether rough or polished, diamonds acquire by friction positive electricity, but do not retain it for more than half an hour.   The natural form of diamonds is derivable from an octahedron, and they never present crystals having one axis longer than the other.   Their structure is very perceptibly lamellar, and therefore, notwithstanding their great hardness, they are brittle and give way in the line of their cleavage, affording a direct means of arriving at their primitive form, the regular octahedron.

The diamond possesses either single or double refraction, according to its different crystalline forms ; its refractive power on light is far greater than it ought to be in the ratio of its density ; the index of refraction being 2·11, whence Newton long ago supposed it to consist of inflammable matter.   Its various forms in nature present a circumstance peculiar to this body ; its faces are rarely terminated by planes, like most other native crystals, but they are often rounded off, and the edges between them are curved.   When these secondary faces are attentively examined with a lens, we remark that they are marked with striæ, sometimes very fine and almost imperceptible, but at others well defined ; and that these striæ are parallel to the edges of the octahedron, and consequently to those of the plates that are applied on the primitive faces of this figure.

Diamonds are usually colorless and transparent ; when colored, their ordinary tint verges upon yellow, or smoke-yellow, approaching sometimes to blackish-brown.   Green diamonds are next to yellow the most common ; the blue possess rarely a lively hue, but they are much esteemed in Scotland.   The rose or pink diamonds are the most valued of the colored kind, and exceed sometimes in price the most limpid ; though generally speaking the latter are the most highly prized.

The geological locality of the diamond seems to be in diluvial gravel, and among conglomerate rocks ; consisting principally of fragments of quartz, or rolled pebbles of quartz mixed with ferruginous sand, which compose sometimes hard aggregated masses.   This kind of formation is called cascalho in Brazil.   Its accompanying minerals are few in number, being merely black oxyde of iron, micaceous iron ore, pisiform iron ore, fragments of slaty jasper, several varieties of quartz, principally amethyst.   In Mr. Heuland's splendid collection there was a Brazilian diamond imbedded in brown iron ore ; another in the same, belonging to M. Schuch, librarian to the Crown Princess of Portugal ; and in the cabinet of M. Eschwege there is a mass of brown iron ore, containing a diamond in the drusy cavity of a green mineral, conjectured to be arseniate of iron.   From these facts it may be inferred with much probability that the matrix or original repository of the diamond of Brazil is brown iron ore, which occurs in beds of slaty quartzose micaceous iron ore, or in beds composed of iron-glance and magnetic iron ore, both of which are apparently subordinate in that country to primitive clay slate.

The loose earth containing diamonds lies always a little way beneath the surface of the soil, towards the lower outlet of broad valleys, rather than upon the ridges of the adjoining hills.

Only two places on the earth can be adduced with certainty as diamond mines, or rather districts ; a portion of the Indian peninsula, and of Brazil.

India has been celebrated from the most remote antiquity as the country of diamonds. Its principal mines are in the kingdoms of Golconda and Visapour, extending from Cape Comorin to Bengal, at the foot of a chain of mountains called the Orixa, which appear to belong to the trap rock formation.   In all the Indian diamond soils, these gems are so dispersed, that they are rarely found directly, even in searching the richest spots, because they are enveloped in an earthy crust, which must be removed before they can be seen.   The stony matter is therefore broken into pieces, and is then, as well as the looser earth, washed in basins scooped out on purpose.   The gravel thus washed is

collected, spread out on a smooth piece of ground, and left to dry. The diamonds are now recognised by their sparkling in the sun, and are picked out from the stones.

The diamond mines of Brazil were discovered in 1728, in the district of Serro-do-Frio. The ground in which they are imbedded has the most perfect resemblance to that of the East Indies, where the diamonds occur. It is a solid or friable conglomerate, consisting chiefly of a ferruginous sand, which encloses fragments of various magnitude of yellow and bluish quartz, of schistose jasper, and grains of gold disseminated with oligist iron ore; all mineral matters different from those that constitute the neighboring mountains; this conglomerate, or species of pudding-stone, almost always superficial, occurs sometimes at a considerable height on the mountainous table-land. The most celebrated diamond mine is that of Mandarga, on the Jigitonhonha, in the district of Serro-do-Frio to the north of Rio Janeiro. The river Jigitonhonha, three times broader than the Seine at Paris, and from 3 to 9 feet deep, is made nearly dry, by drawing the waters off with sluices at a certain season; and the cascalho or diamond-gravel is removed from the channel by various mechanical means, to be washed elsewhere at leisure. This cascalho, the same as the matrix of the gold mines, is collected in the dry season, to be searched into during the rainy; for which purpose it is formed into little mounds of 15 or 16 tons weight each. The washing is carried on beneath an oblong shed, by means of a stream of water admitted in determinate quantities into boxes containing the cascalho. A negro washer is attached to each box; inspectors are placed at regular distances on elevated stools, and whenever a negro has found a diamond, he rises up and exhibits it. If it weighs 17½ carats, he receives his liberty. Many precautions are taken to prevent the negroes from secreting the diamonds. Each squad of workmen consists of 200 negroes, with a surgeon and an almoner or priest.

The flat lands on either side of the river are equally rich in diamonds over their whole surface, so that it becomes very easy to estimate what a piece of ground not yet washed may produce.

It is said that the diamonds surrounded with a greenish crust are of the *first* water, or are the most limpid when cut. The diamonds received in the different mines of the district are deposited once a month in the treasury of Tejuco; and the amount of what was thus delivered from 1801 to 1806, may be estimated at about 18 or 19 thousand carats *per annum*.

On the banks of the torrent called Rio Pardo, there is another mine of diamonds. The ground presents a great many friable rocks of pudding-stone, distributed in irregular strata. It is chiefly in the bed of this stream that masses of cascalho occur, peculiarly rich in diamonds. They are much esteemed, particularly those of a greenish-blue color. The ores that accompany the diamond at Rio Pardo differ somewhat from those of the washing grounds of Mandanga, for they contain no pisiform iron ore; but a great many pebbles of slaty jasper. This table land seems to be very high, probably not less than 5500 feet above the level of the sea.

Tocaya, a principal village of Minas Novas, is 34 leagues to the northeast of Tejuco, in an acute angle of the confluence of the Jigitonhonha and the Rio Grande. In the bed of the streamlets which fall westward into the Jigitonhonha, those rolled white topazes are found which are known under the name of *minas novas* with *blue topazes*, and aquamarine beryls. In the same country are found the beautiful cymophanes or crysoberyls so much prized in Brazil. And it is from the cantons of Indaia and Abaite that the largest diamonds of Brazil come; yet they have not so pure a water as those of the district of Serro-do-Frio, but incline a little to the lemon yellow.

Diamonds are said to come also from the interior of the island of Borneo, on the banks of the river Succadan, and from the peninsula of Malacca.

It is known that many minerals become phosphorescent by heat, or exposure to the sun's light. Diamonds possess this property, but all not in equal degree, and certain precautions must be observed to make it manifest. Diamonds need to be exposed to the sunbeam for a certain time, in order to become self-luminous; or to the blue rays of the prismatic spectrum, which augment still more the faculty of shining in the dark. Diamonds susceptible of phosphorescence exhibit it either after a heat not raised to redness, or the electric discharge. They possess not only a great refractive power in the mean ray of light, but a high dispersive agency, which enables them to throw out the most varied and vivid colors in multiplied directions.

Louis de Berquem discovered, in 1476, the art of cutting diamonds by rubbing them against one another, and of polishing them with their own powder. These operations may be abridged by two methods: 1. By availing ourselves of the direction of the laminæ of the diamond to split them in that direction, and thus to produce several facets. This process is called cleaving the diamond. Some, which appear to be *macle* crystals, resist this mechanical division, and are called *diamonds of nature*. 2. By sawing the diamonds by means of a very delicate wire, coated with diamond powder.

Diamonds take precedence of every gem for the purposes of dress and decoration; and

hence the price attached to those of a pure water increases in so rapid a proportion, that beyond a certain term there is no rule of commercial valuation. The largest diamond that is known seems to be that of the Rajah of Mattan, in the East Indies. It is of the purest water, and weighs 367 carats, or at the rate of 4 grains to a carat, upwards of 3 ounces troy. It is shaped like an egg, with an indented hollow near the smaller end; it was discovered at Landak about 100 years ago; and though the possession of it has cost several wars, it has remained in the Mattan family for 90 years. A governor of Batavia, after ascertaining the qualities of the gem, wished to be the purchaser, and offered 150,000 dollars for it, besides two war brigs with their guns and ammunition, together with a certain number of great guns, and a quantity of powder and shot. But this diamond possessed such celebrity in India, and was regarded as a talisman involving the fortunes of the Rajah and his family, that he refused to part with it at any price.

The diamond possessed, in the time of the traveller Tavernier, by the emperor of Mogul, a kingdom now no more, weighed 279 carats, and was reckoned worth upwards of 400,000*l.* sterling. It was said to have lost the half of its original weight in the cutting. After these prodigious gems, the next are:—1. That of the emperor of Russia, bought by the late empress Catharine, which weighs 193 carats. It is said to be of the size of a pigeon's egg, and to have been bought for 90,000*l.*, besides an annuity to the Greek merchant of 4000*l.* It is reported that the above diamond formed one of the eyes of the famous statue of Sheringan, in the temple of Brama, and that a French grenadier, who had deserted into the Malabar service, found the means of robbing the pagoda of this precious gem; and escaped with it to Madras, where he disposed of it to a ship captain for 2,000*l.*, who resold it to a Jew for 12,000*l.* From him it was transferred for a large sum to the Greek merchant. 2. That of the emperor of Austria, which weighs 139 carats, and has a slightly yellowish hue. It has, however, been valued at 100,000*l.* 3. That of the king of France, called the Regent or Pitt diamond, remarkable for its form and its perfect limpidity. Although it weighs only 136 carats, its fine qualities have caused it to be valued at 160,000*l.*, though it cost only 100,000*l.*

The largest diamond furnished by Brazil, now in possession of the crown of Portugal, weighs, according to the highest estimates, 120 carats. It was found in the streamlet of Abaite, in a clay-slate district.

The diamonds possessed of no extraordinary magnitude, but of a good form and a pure water, may be valued by a certain standard rule. In a brilliant, or rose-diamond of regular proportions, so much is cut away that the weight of the polished gem does not exceed one half the weight of the diamond in the rough state; whence the value of a cut diamond is esteemed equal to that of a similar rough diamond of double weight, exclusive of the cost of workmanship. The weight and value of diamonds are reckoned by carats of 4 grains each; and the comparative value of two diamonds of equal quality but different weights, is as the squares of these weights respectively. The average price of rough diamonds that are worth working is about 2*l.* for one of a single carat; but as a polished diamond of one carat must have taken one of 2 carats, its price in the rough state is double the square of 2*l.*, or 8*l.* Therefore, to estimate the value of a wrought diamond, ascertain its weight in carats, double that weight, and multiply the square of this product by 2*l.*

Hence, a wrought diamond of 1 carat is worth   £ 8

2	—	32
3	—	72
4	—	128
5	—	200
6	—	288
7	—	392
8	—	512
9	—	612
10	—	800
20	—	3200,

beyond which weight the prices can no longer rise in this geometrical progression, from the small number of purchasers of such expensive toys. A very trifling spot or flaw of any kind lowers exceedingly the commercial value of a diamond.

Diamonds are used not only as decorative gems, but for more useful purposes, as for cutting glass by the glazier, and all kinds of hard stones by the lapidary.

On the structure of the glazier's diamond, we possess some very interesting observations and reflections by Dr. Wollaston. He remarks, that the hardest substances brought to a sharp point scratch glass, indeed, but do not cut it, and that diamond alone possessed that property; which he ascribes to the peculiarity of its crystallization in rounded faces, and curvilinear edges. For glass-cutting, those rough diamonds are always selected which are sharply crystallized, hence called diamond sparks; but cut

diamonds are never used. The inclination to be given to a set diamond in cutting glass is comprised within very narrow limits; and it ought, moreover, to be moved in the direction of one of its angles. The curvilinear edge adjoining the curved faces, entering as a wedge into the furrow opened up by itself, thus tends to separate the parts of the glass; and in order that the crack which causes the separation of the vitreous particles may take place, the diamond must be held almost perpendicular to the surface of the glass. The Doctor proved this theory by an experiment. If, by suitable cutting with the wheel, we make the edges of a spinel ruby, or corundum-telesie (sapphire) curvilinear, and the adjacent faces curved, these stones will cut glass as well as a glazier's diamond, but being less hard than it, they will not preserve this property so long. He found that upon giving the surface of even a fragment of flint the same shape as that of the cutting diamond, it acquired the same property; but, from its relative softness, was of little duration. The depth to which the fissure caused by the glazier's diamond penetrates, does not seem to exceed the two-hundredth of an inch.

I shall here introduce Mr. Milburn's valuable observations on the choice of rough diamonds, as published in his work on *Oriental Commerce*.

The color should be perfectly crystalline, resembling a drop of clear spring water, in the middle of which you will perceive a strong light, playing with a great deal of spirit. If the coat be smooth and bright, with a little tincture of green in it, it is not the worse, and seldom proves bad, but if there is a mixture of yellow with green, then beware of it; it is a soft greasy stone, and will prove bad.

If the stone has a rough coat, so that you can hardly see through it, and the coat be white and look as if it were rough by art, and clear of flaws or veins, and no blemish cast in the body of the stone (which may be discovered by holding it against the light), the stone will prove good.

It often happens that a stone will appear of a reddish hue on the outward coat, not unlike the color of rusty iron, yet by looking through it against the light, you may observe the heart of the stone to be white (and if there be any black spots, or flaws, or veins in it, they may be discovered by a true eye, although the coat of the stone be the same), and such stones are generally good and clear.

If a diamond appears of a greenish bright coat, resembling a piece of green glass, inclining to black, it generally proves hard, and seldom bad; such stones have been known to have been of the first water, and seldom worse than the second; but if any tincture of yellow seems to be mixed with it, you may depend on its being a very bad stone.

All stones of a milky cast, whether the coat be bright or dull, if ever so little inclining to a bluish cast, are naturally soft, and in danger of being flawed in the cutting; and though they should have the good fortune to escape, yet they will prove dead and milky, and turn to no account.

All diamonds of cinnamon color are dubious; but if of a bright coat mixed with a little green, then they are certainly bad, and are accounted among the worst of colors. You will meet with a great many diamonds of a rough cinnamon-colored coat, opaque; this sort is generally very hard, and, when cut, contain a great deal of life and spirit; but the color is very uncertain; it is sometimes white, sometimes brown, and sometimes of a fine yellow. Rough diamonds are frequently *beamy*, that is, look fair to the eye, yet are so full of veins to the centre, that no art or labor can polish them. A good diamond should never contain small spots of a white or gray color of a nebulous form; it should be free from small reddish and brownish grains, that sometimes occur on their surface, or in their interior. A good diamond should split readily in the direction of the cleavage; it sometimes happens, however, that the folia are curved, as is the case in twin crystals. When this happens, the stone does not readily cut and polish, and is therefore of inferior value.

In the cut and polished gem, the thickness must always bear a certain proportion to the breadth. It must not be too thin nor thick; for, when too thin, it loses much of its fire, and appears not unlike glass.

The term *carat* is said to be derived from the name of a bean, the produce of a species of *erythina*, a native of the district of Shangallas, in Africa; a famous mart of gold-dust. The tree is called *kuara*, a word signifying sun in the language of the country; because it bears flowers and fruit of a flame color. As the dry seeds of this pod are always of nearly uniform weight, the savages have used them from time immemorial to weigh gold. The beans were transported into India, at an ancient period, and have been long employed there for weighing diamonds. The carat of the civilized world is, in fact, an imaginary weight, consisting of 4 nominal grains, a little lighter than 4 grains troy (*poids de marc*); it requires 74 carat grains and $\frac{1}{16}$ to equipose 72 of the other.

In valuing a cut diamond, we must reckon that one half of its weight has been lost in the lapidary's hands; whence its weight in this state should be doubled before we calculate its price by the general rule for estimating diamonds. The French multiply

by 48 the square of this weight, and they call the product in francs the value of the diamond. Thus, for example, a cut diamond of 10 carats would be worth (10×2)* $\times 48 = 19,200$ francs, or 768*l*., allowing only 25 francs to the pound sterling.

The diamond mines of Brazil have brought to its government, from the year 1730 till 1814, 3,023,000 carats; being at the average rate annually of 36,000 carats, or a little more than 16 lbs. weight. They have not been so productive in the later years of that period; for. according to Mr. Mawe, between 1801 and 1806, only 115,675 carats were obtained, being 19,279 a year. The actual expenses incurred by the government, during this interval, was 4,419,700 francs; and, deducting the production in gold from the washings of the diamond gravel, or *cascalho*, it is found that the rough diamonds cost in exploration, per carat, 38 francs 20 c., or nearly 31*s.* British money. The contraband is supposed to amount to one third of the above legitimate trade. Brazil is almost the only country where diamonds are mined at the present day; it sends annually to Europe from 25 to 30 thousand carats, or from 10 to 16½ lbs.

DIAMONDS, *cutting of.* Although the diamond is the hardest of all known substances, yet it may be split by a steel tool, provided a blow be applied; but this requires a perfect knowledge of the structure, because it will only yield to such means in certain directions. This circumstance prevents the workman from forming facettes or planes generally, by the process of splitting; he is therefore obliged to resort to the process of abrasion, which is technically called cutting. The process of cutting is effected by fixing the diamond to be cut on the end of a stick, or handle, in a small ball of cement, that part which is to be reduced being left to project. Another diamond is also fixed in a similar manner; and the two stones being rubbed against each other with considerable force, they are mutually abraded, flat surfaces, or facettes, being thereby produced. Other facettes are formed by shifting the diamonds into fresh positions in the cement, and when a sufficient number are produced, they are fit for polishing. The stones, when cut, are fixed for this purpose, by imbedding them in soft solder, contained in a small copper cup, the part, or facette, to be polished, being left to protrude.

A flat circular plate of cast-iron is then charged with the powder produced during the abrasion of the diamonds; and by this means a tool is formed which is capable of producing the exquisite lustre so much admired on a finely-polished gem. Those diamonds that are unfit for working, on account of the imperfection of their lustre or color, are sold, for various purposes, under the technical name of Bort. Stones of this kind are frequently broken in a steel mortar, by repeated blows, until they are reduced to a fine powder, which is used to charge metal plates, of various kinds, for the use of jewellers, lapidaries, and others. Bort, in this state of preparation, is incapable of polishing any gems; but it is used to produce flat surfaces on rubies and other precious stones.

Fine drills are made of small splinters of bort, which are used for drilling small holes in rubies, and other hard stones, for the use of watch-jewellers, gold and silver wire-drawers, and others, who require very fine holes drilled in such substances. These drills are also used to pierce holes in china, where rivets are to be inserted; also for piercing holes in artificial enamel teeth, or any vitreous substances, however hard.

DIAMOND MICROSCOPES were first suggested by Dr. Goring, and have been well executed by Mr. Pritchard. Previous to grinding a diamond into a spherical figure, it should be ground flat and parallel upon both sides, that by looking through it, as opticians try flint glass, we may see whether it has a double or triple refractive power, as many have, which would render it useless as a lens. Among the 14 different crystalline forms of the diamond, probably the octahedron and the cube are the only ones that will give single vision. It will, in many cases, be advisable to grind diamond lenses, plano-convex, both because this figure gives a low spherical aberration, and because it saves the trouble of grinding one side of the gem. A concave tool of cast iron, paved with diamond powder, hammered into it by a hardened steel punch, was employed by Mr. Pritchard. This ingenious artist succeeded in completing a double convex of equal radii, of about $\frac{1}{25}$ of an inch focus, bearing an aperture of $\frac{1}{30}$ of an inch with distinctness upon opaque objects, and its entire diameter upon transparent ones. This lens gives vision with a trifling chromatic aberration; in other respects, like Dr. Goring's Amician reflector, but without its darkness, its light is said to be superior to that of any compound microscope whatever, acting with the same power, and the same angle of aperture. The advantage of seeing an object without *aberration* by the interposition of only a single magnifier, instead of looking at a picture of it with an eye glass, is evident. We thus have a simple direct view, whereby we shall see more accurately and minutely the real texture of objects.

DIAPER is the name of a kind of cloth, used chiefly for table linen. It is known among the French by the name of *toile fourré*, and is ornamented with the most extens-

figures of any kind of tweeled cloth, excepting damask. The mounting of a loom for working diaper is, in principle, much the same as a draw-loom, but the figures being less extensive, the mounting is more simple, and is wrought entirely by the weaver, without the aid of any other person. As tweeled cloths, of any number of leaves, are only interwoven at those intervals when one of the leaves is raised, the woof above, and the warp below, is kept floating or flushed, until the intersection takes place. Of consequence, the floating yarn above appears across the fabric, and that below longitudinally. This property of tweeled cloths is applied to form the ornamental figures of all kinds of tweeled goods, merely by reversing the floating yarn when necessary. In the simpler patterns, this is effected by a few additional leaves of treddles; but when the range of pattern becomes too great to render this convenient, an apparatus called a *back harness* is employed, and the cloth woven with this mounting is called diaper. Diapers are generally five-leaf tweels; that is to say, every warp floats under four threads of woof, and is raised, and of course interwoven with the fifth. This is done either successively, forming diagonals at 45° upon the cloth, or by intervals of two threads, which is called the broken tweel. The latter is generally, if not universally, adopted in the manufacture of diaper. The reason of preferring the broken to the regular tweel, where ornaments are to be formed, is very obvious. The whole depending upon reversed flushing to give the appearance of oblique or diagonal lines, through either, would destroy much of the effect, and materially injure the beauty of the fabric. The broken tweel, on the contrary, restores to the tweeled cloth a great similarity of appearance to plain, or alternately interwoven fabrics, and at the same time preserves the facility of producing ornaments by reversing the flushing. The simplest kinds of reversed tweels will be found described under TEXTILE FABRICS.

DIASTASE. This curious substance, extracted by water from crushed malt, and precipitated from that infusion by alcohol, as is described under FERMENTATION, has been made the subject of new researches by M. Guerin Varry. The conclusions deducible from his interesting experiments are the following :—

1. One part of diastase, dissolved in 30 parts of cold water, put with 408 parts of potato starch out of contact of air, did not exercise the slightest action upon this substance in the course of 63 days, under a temperature varying from 68° to 79° Fahr.

2. Two parts of dinstase do not in the course of an hour cause the globules of three parts of starch to burst, at a temperature approaching very nearly to that of the hot water which bursts them into a paste. It follows that diastase acts no part in the process of germination, towards eliminating the teguments of the starch, or transforming its interior portion into sugar, and a gummy matter assimilated by plants.

3. Diastase liquefies and saccharifies the paste of starch without absorption or disengagement of gas; a reaction which takes place equally in vacuo as in the open air.

4. 100 parts of starch made into a paste with 39 times their weight of water, mixed with 6·13 parts of diastase dissolved in 40 parts of water, and kept for an hour between 140° and 149° Fahr., afforded 86·91 parts of sugar.

5. A paste containing 100 parts of starch, and 1393 parts of water, put in contact with 12·25 parts of diastase dissolved in 367 parts of cold water, having been maintained at 68° Fahr. during 24 hours, produced 77·64 parts of sugar.

6. The preceding experiment, repeated at the temperature of melting ice, afforded at the end of 2 hours, 11·82 parts of sugar.

7. The most favorable proportions and circumstances for the production of a great quantity of sugar, are a slight excess of diastase or barley malt (at least 25 per cent. of the latter), about 50 parts of water to one of starch, and a temperature between 140° and 149° Fahr. It is of the greatest consequence for the saccharification to take place as speedily as possible, so that the sugar produced may not be left in contact with much gummy matter (*dextrine*), in which case the diastase will not convert the latter into sugar. In fact, the liquefaction and saccharification should proceed simultaneously.

8. The sugar of starch, prepared either with diastase or sulphuric acid, crystallizes in cauliflowers, or in prisms with rhomboidal facets. It has the same composition as sugar of grapes.

9. Diastase even in excess does not saccharify the gummy matter dissolved in the water along with the starch sugar, but when the gum is insulated, it is convertible almost entirely into sugar.

10. Gum arabic, cane sugar, and beer yeast, suffer no change from diastase.

11. A watery solution of diastase readily decomposes on keeping, either in contact or out of contact of air.

12. When starch-sugar, whether obtained by means of diastase or sulphuric acid, is submitted to the spirituous fermentation, the sum of the weights of the alcohol, carbonic acid, and water of crystallization of the sugar, is less than the weight of the sugar by about 3½ per cent. This difference proceeds in a great measure from the form-

ation of some acetic acid, lactic acid, volatile oil, and probably some other unknown products in the act of fermentation.

DIMITY is a kind of cotton cloth originally imported from India, and now manufactured in great quantities in various parts of Britain, especially in Lancashire. Dr. Johnson calls it *dimmity*, and describes it as a kind of fustian. The distinction between fustian and dimity seems to be, that the former designates a common tweeled cotton cloth of a stout fabric, which receives no ornament in the loom, but is most frequently dyed after being woven. Dimity is also a stout cotton cloth, but not usually of so thick a texture; and is ornamented in the loom, either with raised stripes or fancy figures; is seldom dyed, but usually worn white, as for bed and bed-room furniture. The striped dimities are the most common; they require less labor in weaving than the others; and the mounting of the loom being more simple, and consequently less expensive, they can be sold at much lower rates. See Textile Fabrics, for particular details of the plan of mounting them.

DIES FOR STAMPING. (*Coins*, Fr.; *Münzstampeln*, Germ.) The first circumstance that claims particular attention in the manufacture of dies, is the selection of the best kind of steel for the purpose, and this must in some measure be left to the experience of the die-forger, who, if well skilled in his art, will be able to form a tolerably correct judgment of the fitness of the metal for the purpose, by the manner in which it works upon the anvil. It should be rather fine-grained than otherwise, and above all things perfectly even and uniform in its texture, and free from spots and patches finer or coarser than the general mass. But the very fine and uniform steel with a silky fracture, which is so much esteemed for some of the purposes of cutlery, is unfit for our present purpose, from the extreme facility with which it acquires great hardness by pressure, and its liability to cracks and flaws. The very coarse-grained or highly crystalline steel is also equally objectionable; it acquires fissures under the die-press, and seldom admits of being equally and properly hardened. The object, therefore, is to select a steel of a medium quality as to fineness of texture, not easily acted upon by dilute sulphuric acid, and exhibiting a uniform texture when its surface is washed over with a little aqua-fortis, by which its freedom from pins of iron, and other irregularities of composition, is sufficiently indicated.

The best kind of steel being thus selected, and properly forged at a high heat into the rough die, it is softened by very careful annealing, and in that state, having been smoothed externally, and brought to a table in the turning lathe, it is delivered to the engraver.

The process of annealing the die consists in heating it to a bright cherry red, and suffering it to cool gradually, which is best effected by bedding it in a crucible or iron pot of coarsely-powdered charcoal, that of animal substances being generally preferred. In this operation it is sometimes supposed that the die, or at least its superficial parts, becomes super-carbonized, or highly-converted steel, as it is sometimes called; but experience does not justify such an opinion, and I believe the composition of the die is scarcely, certainly not materially, affected by the process, for it does not remain long enough in the fire for the purpose.

The engraver usually commences his labors by working out the device with small steel tools, in intaglio; he rarely begins in relief (though this is sometimes done); and having ultimately completed his design, and satisfied himself of its general effect and correctness, by impressions in clay, and dabs, or casts in type metal, the die is ready for the important operation of hardening, which, from various causes, a few of which I shall enumerate, is a process of much risk and difficulty; for should any accident now occur, the labor of many months may be seriously injured, or even rendered quite useless.

The process of hardening soft steel is in itself very simple, though not very easily explained upon mechanical or chemical principles. We know by experience that it is a property of this highly valuable substance to become excessively hard, if heated and suddenly cooled; if, therefore, we heat a bar of soft malleable and ductile steel red hot, and then suddenly quench it in a large quantity of cold water, it not only becomes hard, but fragile and brittle. But as a die is a mass of steel of considerable dimensions, this hardening is an operation attended by many and peculiar difficulties, more especially as we have at the same time to attend to the careful preservation of the engraving. This is effected by covering the engraved face of the die with a protecting face, composed of fixed oil of any kind, thickened with powdered charcoal: some persons add pipe-clay, others use a pulp of garlic, but pure lamp-black and linseed oil answer the purpose perfectly. This is thinly spread upon the work of the die, which, if requisite, may be further defended by an iron ring; the die is then placed with its face downwards in a crucible, and completely surrounded by powdered charcoal. It is heated to a suitable temperature, that is, about cherry red, and in that state is taken out with proper tongs, and plunged into a body of cold water, of such magnitude as not

to become materially increased in temperature; here it is rapidly moved about, until all noise ceases, and then left in the water till quite cool. In this process it should produce a bubbling and hissing noise; if it pipes and sings, we may generally apprehend a crack or fissure.

No process has been found to answer better than the above simple and common mode of hardening dies, though others have had repeated and fair trials. It has been proposed to keep up currents and eddies of cold water in the hardening cistern, by means of delivery-pipes, coming from a height; and to subject the hot die, with its face uppermost, to a sudden and copious current of water, let upon it from a large pipe, supplied from a high reservoir; but these means have not in any way proved more successful, either in saving the die or in giving it any good qualities. It will be recollected, from the form of the die, that it is necessarily only, as it were, case-hardened; the hardest strata being outside, and the softer ones within, which envelop a core, something in the manner of the successive coats of an onion; an arrangement which we sometimes have an opportunity of seeing displayed in dies which have been smashed by a violent blow.

The hardening having been effected, and the die being for the time safe, some further steps may be taken for its protection; one of these consists in a very mild kind of tempering, produced by putting it into water, gradually raised to the boiling point, till heated throughout, and then suffering it gradually to cool. This operation renders the die less apt to crack in very cold weather. A great safeguard is also obtained by thrusting the cold die into a red-hot iron ring, which just fits it in that state, and which, by contracting as it cools, keeps its parts together under considerable pressure, preventing the spreading of external cracks and fissures, and often enabling us to employ a split or die for obtaining punches, which would break to pieces without the protecting ring.

If the die has been successfully hardened, and the protecting paste has done its duty, by preserving the face from all injury and oxydizement, or burning, as it is usually called, it is now to be cleaned and polished, and in this state constitutes what is technically called a MATRIX; it may, of course, be used as a multiplier of medals, coins, or impressions, but it is not generally thus employed, for fear of accidents happening to it in the coining press, and because the artist has seldom perfected his work upon it in this state. It is, therefore, resorted to for the purpose of finishing a PUNCH, or steel impression for relief. For this purpose a proper block of steel is selected, of the same quality, and with the same precautions as before, and being carefully annealed, or softened, is turned like the matrix, perfectly true and flat at the bottom, and obtusely conical at top. In this state, its conical surface is carefully compressed by powerful and proper machinery upon the matrix, which, being very hard, soon allows it to receive the commencement of an impression; but in thus receiving the impression, it becomes itself so hard by condensation of texture as to require, during the operation, to be repeatedly annealed, or softened; otherwise it would split into small superficial fissures, or would injure the matrix; much practical skill is therefore required in taking this impression, and the punch, at each annealing, must be carefully protected, so that the work may not be injured.

Thus, after repeated blows in the die-press, and frequent annealing, the impression from the matrix is at length perfected, or brought completely up, and having been retouched by the engraver, is turned, hardened, and collared, like the matrix, of which it is now a complete impression in relief, and, as we have before said, is called a punch.

This punch becomes an inexhaustible parent of dies, without further reference to the original matrix; for now by impressing upon it plugs of soft steel, and by pursuing with them an exactly similar operation to that by which the punch itself was obtained, we procure impressions from it to any amount, which of course are fac-similes of the matrix, and these dies being turned, hardened, polished, and, if necessary, tempered, are employed for the purposes of coinage.

The distinction between striking medals and common coin is very essential, and the work upon the dies is accordingly adjusted to each. Medals are usually in very high relief, and the effect is produced by a succession of blows; and as the metal in which they are struck, be it gold, silver, or copper, acquires considerable hardness at each stroke of the press, they are repeatedly annealed during the process of bringing them up. In a beautiful medal, which Mr. Wyon some time since completed for the Royal Navy College, the obverse represents a head of the King, in very bold relief; it required thirty blows of a very powerful press to complete the impression, and it was necessary to anneal each medal after every third blow, so that they went ten times into the fire for that purpose. In striking a coin or medal, the lateral spread of the metal, which otherwise would ooze out as it were from between the dies, is prevented by the application of a steel collar, accurately turned to the dimensions of the dies, and which, when left plain, gives to the edge of the piece a finished and polished appearance; it is

sometimes grooved, or milled, or otherwise ornamented, and occasionally lettered, in which case it is made in three separate and moveable pieces, confined by a ring, into which they are most accurately fitted, and so adjusted that the metal may be forced into the letters by its lateral spread, at the same time that the coin receives the blow of the screw-press.

Coins are generally completed by one blow of the coining-press. These presses are worked in the Royal Mint by machinery, so contrived that they shall strike, upon an average, sixty blows in a minute; the blank piece, previously properly prepared and annealed, being placed between the dies by part of the same mechanism.

The number of pieces which may be struck by a single die of good steel, properly hardened and duly tempered, not unfrequently amounts at the Mint to between three and four hundred thousand, but the average consumption of dies is of course much greater, owing to the variable qualities of steel, and to the casualties to which the dies are liable: thus, the upper and lower die are often violently struck together, owing to an error in the layer-on, or in that part of the machinery which ought to put the blank into its place, but which now and then fails so to do. This accident very commonly arises from the boy who superintends the press neglecting to feed the hopper of the layer-on with blank pieces. If a die is too hard, it is apt to break or split, and is especially subject to fissures, which run from letter to letter upon the edge. If too soft, it swells, and the collar will not rise and fall upon it, or it sinks in the centre, and the work becomes distorted and faulty. He, therefore, who supplies the dies for an extensive coinage has many accidents and difficulties to encounter. There are eight presses at the Mint, frequently at work for ten hours each day, and the destruction of eight pair of dies per day (one pair for each press) may be considered a fair average result, though they much more frequently fall short of, than exceed this proportion. It must be remembered that each press produces 3600 pieces per hour, but, making allowance for occasional stoppages, we may reckon the daily produce of each press at 30,000 pieces; the eight presses, therefore, will furnish a diurnal average of 240,000 pieces.

DIGESTER is the name of a strong kettle or pot of small dimensions, made very strong, and mounted with a safety valve in its top. Papin, the contriver of this apparatus, used it for subjecting bones, cartilages, &c. to the solvent action of high-pressure steam, or highly heated water, whereby he proposed to facilitate their digestion in the stomach. This contrivance is the origin of the French cookery pans, called *autoclaves*, because the lid is self-keyed, or becomes steam-tight by turning it round under clamps or ears at the sides, having been previously ground with emery to fit the edge of the pot exactly. In some autoclaves the lid is merely laid on with a fillet of linen as a lute, and then secured in its place by means of a screw bearing down upon its centre from an arched bar above. The safety valve is loaded either by a weight placed vertically upon it, or by a lever of the second kind pressing near its fulcrum, and acted upon by a weight which may be made to bear upon any point of its graduated arm.

Chevreul has made a useful application of the digester to vegetable analysis. His instrument consists of a strong copper cylinder, into which enters a tight cylinder of silver, having its edge turned over at right angles to the axis of the cylinder, so as to form the rim of the digester. A segment of a copper sphere, also lined with silver, stops the aperture of the silver cylinder, being applied closely to its rim. It has a conical valve pressed with a spiral spring, of any desired force, estimated by a steelyard. This spring is enclosed within a brass box perforated with four holes; which may be screwed into a tapped orifice in the top of the digester. A tube screwed into another hole serves to conduct away the condensable vapors at pleasure into a Woulfe's apparatus.

DISTILLATION (Eng. and Fr.; *Branntweinbrennerei*, Germ.) means, in the commercial language of this country, the manufacture of intoxicating spirits; under which are comprehended the four processes, of *mashing* the vegetable materials, *cooling* the worts, exciting the vinous *fermentation*, and separating by a peculiar vessel, called a *still*, the alcohol combined with more or less water. This art of evoking the fiery demon of drunkenness from his attempered state in wine and beer, was unknown to the ancient Greeks and Romans. It seems to have been invented by the barbarians of the north of Europe, as a solace to their cold and humid clime; and was first made known to the southern nations in the writings of Arnoldus de Villa Nova, and his pupil, Raymond Lully of Majorca, who declares this admirable essence of wine to be an emanation of the Divinity, an element newly revealed to man, but hid from antiquity, because the human race were then too young to need this beverage, destined to revive the energies of modern decrepitude. He further imagined that the discovery of this *aqua vitæ*, as it was called, indicated the approaching consummation of all things—the end of this world. However much he erred as to the value of this remarkable essence, he truly predicted its vast influence upon humanity, since to both civilized and savage nations it has realized greater ills than were threatened in the fabled box of Pandora.

I shall consider in this place the first three of these subjects, reserving for the article STILL an account of the construction and use of that apparatus.

Whiskey, from the Irish word Usquebaugh, is the British name of the spirituous liquor manufactured by our distillers, and corresponds to the *Eau de vie* of the French, and the *Branntwein* of the Germans. It is generated by that intestine change which grape juice and other glutino-saccharine liquids spontaneously undergo when exposed to the atmosphere at common temperatures; the theory of which will be expounded under the article FERMENTATION. The production of whiskey depends upon the simple fact, that when any vinous fluid is boiled, the alcohol, being very volatile, evaporates first, and may thereby be separated from the aqueous vegetable infusion in which it took its birth. Sugar is the only substance which can be transformed into alcohol. Whatsoever fruits, seeds, or roots afford juices or extracts capable of conversion into vinous liquor, either contain sugar ready formed, or starch susceptible of acquiring the saccharine state by proper treatment. In common language, the intoxicating liquor obtained from the sweet juices of fruits is called wine; and that from the infusions of farinaceous seeds, beer; though there is no real difference between them in chemical constitution. A similar beverage, though probably less palatable, is procurable from the juices and infusions of many roots, by the process of fermentation. Wine, cider, beer, and fermented wash of every kind, when distilled, yields an identical intoxicating spirit, which differs in these different cases merely in flavor, in consequence of the presence of a minute quantity of volatile oils of different odors.

I. The juices of sweet fruits contain a glutinous ingredient which acts as a ferment in causing their spontaneous change into a vinous condition; but the infusions of seeds, even in their germinated or malted state, require the addition of a glutinous substance called yeast, to excite the best fermentation. In the fabrication of wine or beer for drinking, the fermentative action should be arrested before all the fruity saccharum is decomposed; nor should it on any account be suffered to pass into the acetous stage; whereas for making distillery wash, that action should be promoted as long as the proportion of alcohol is increased, because the formation of a little acetic acid is not injurious to the quality of the distilled spirit, but rather improves its flavor by the addition of acetic ether, while all the undecomposed sugar is lost. Distillers operate upon the saccharine matter from corn of various kinds in two methods; in the first they draw off a pure watery extract from the grain, and subject this species of wort to fermentation; in the second they ferment and distil the infused mass of grains. The former is the practice of the distillers in the United Kingdom, and is preferable on many accounts; the latter, which is adopted in Germany, Holland, and the north of Europe, is less economical, more uncertain in the product, and affords a cruder spirit, in consequence of the fetid volatile oil evolved from the husks in the still. The substances employed by the distillers may be distributed into the following classes :—

1. Saccharine juices. At the head of these stands cane-juice, which fresh from the mill contains from 12 to 16 per cent. of raw sugar, and like the must of the grape enters into the vinous fermentation without the addition of yeast, affording the species of spirit called Rum, which is possessed of a peculiar aroma derived from an essential oil in the cane. An inferior sort of rum is fabricated from molasses, mixed with the skimmings and washings of the sugar pans. When molasses or treacle is diluted with twenty times its weight of warm water, and when the mixture has cooled to 78° F., if one twelfth of its weight of yeast be added, fermentation will speedily ensue, and an ardent spirit will be generated, which when distilled has none of the aroma of rum; proving this to reside in the immediate juice or substance of the cane, and to be dissipated at the high temperature employed in the production of molasses. Though the cane juice will spontaneously undergo the vinous fermentation, it does so more slowly and irregularly than the routine of business requires, and therefore is quickened by the addition of the lees of a preceding distillation. So sensible are the rum distillers of the advantage of such a plan, that they soak woollen cloths in the yeast of the fermenting vats, in order to preserve a ferment from one sugar season to another. In Jamaica and some other of our colonies, 50 gallons of spent wash or lees are mixed with 6 gallons of molasses, 36 gallons of sugar-pan skimmings (a substance rich in aroma), and 8 gallons of water; in which mixture there is about one twelfth part of solid saccharum. Those who attend more to the quality than the quantity of their rum, will use a smaller proportion of the spent wash, which is always empyreumatic, and imparts more or less of its odor to the spirit distilled from it. The fermentation is seldom complete in less than 9 days, and most commonly it requires from 12 to 15; the period being dependant upon the capacity of the fermenting tun, and the quality of its contents. The liquid now becomes clear, the froth having fallen to the bottom, and few bubbles of gas are extricated from it, while its specific gravity is reduced from 1·050 down to 0·992. The sooner it is subjected to distillation after this period, the better, to prevent

the loss of alcohol by the supervention of the acetous stage of fermentation, an accident very liable to happen in the sugar colonies. The crude spirit obtained from the large single still at the first operation, is rectified in a smaller still. About 114 gallons of rum, proof strength, specific gravity 0·920, are obtained from 1200 gallons of wash. Now these 1200 gallons weigh 12,600 lbs., and contain nearly one eighth of their weight of sugar=1575 lbs.; which should yield nearly its own weight of proof spirit, whose bulk is $=\frac{1575}{0·92}=1712$ pound measures$=171·2$ gallons; whereas only 114 are obtained; proving the processes to be conducted in a manner far from economical, even with every reasonable allowance.

Mr. Edwards gives the following estimate: "The total amount of sweets from an estate in Jamaica which makes 200 hogsheads of sugar, is 16,666 gallons. The wash set at the rate of 12 per cent. sweets should return 34,720 gallons of low wines, which should give 14,412 gallons of rum, or 131 puncheons of 110 gallons each."

By my own experiments on the quantity of proof spirit obtainable from molasses by fermentation (afterwards to be detailed), one gallon of sweets should yield one gallon of spirit; and hence the above 16,666 gallons should have afforded the same bulk of rum. But here we are left somewhat in the dark, by not knowing the specific gravity of the rum spoken of by Mr. Edwards. The only light let in upon us is when he mentions rum oil-proof, that is, a spirit in which olive oil will sink; indicating a density nearly the same with our actual excise proof, for olive oil at 60° F. has the specific gravity 0·919. When a solution of sugar of the proper strength is mixed with wine lees, and fermented, it affords a spirit by distillation not of the rum, but of the brandy flavor.

The sweet juices of palm trees and cocoa nuts, as also of the maple, and ash, birch, &c., when treated like cane juice afford vinous liquids from which ardent spirits, under various names, are obtained; as *arrack*, &c.; the quantity being about 50 pounds of alcohol of 0·825 for every 100 pounds of solid saccharine extract present. Honey similarly treated affords the metheglin so much prized by our ancestors. Good whey, freed from curd by boiling, will yield 4 per cent. of spirit of wine, when fermented with the addition of a little yeast.

2. The juices of apples, pears, currants, and such fruits, afford by fermentation quantities of alcohol proportional to the sugar they contain. But the quality of the spirit is much better when it is distilled from vinous liquids of a certain age, than from recently fermented must. Cherries are employed in Germany, and other parts of the Continent, for making a high-flavored spirit called *Kirsch-wasser*, or cherry water. The fully ripe fruit is crushed by a roller press, or an edge-stone mill, along with the kernels; the pulp is fermented in a mass, the liquid part is then drawn off, and distilled. More or less prussic acid enters from the kernels into this spirit, which renders it very injurious, as a liquor, to many constitutions. I was once nearly poisoned by swallowing a wine glass of it in the valley of Chamouni. The ripened red fruit of the mountain ash constitutes a good material for vinous fermentation. The juice being mixed with some water and a little yeast, affords when well fermented, according to Hermstaedt, 12 pounds, or 1¼ gallons, of alcohol from 2 bushels of the ripe berries.

3. Many roots contain sugar, particularly beet, from which no less than 7 per cent. of it may be extracted by judicious means. Hermstaedt recommends to mash the steam boiled clean roots, and add to the paste two thirds of its weight of boiling water, and a thirtieth of its weight of ground malt, mixing the materials well, and then leaving them three hours in a covered vessel. The mixture must now be passed through a wire sieve, with meshes of one third of an inch square each; the residuum is washed with a little cold water, and, when the temperature has fallen to 77° F., the proper quantity of yeast must be added, and the fermentation suffered to proceed in a covered tun. In 5 or 6 days it will be complete, and will afford by distillation, from 100 pounds of beet root, about 10 or 12 pounds of proof spirits. Carrots and parsnips, when similarly treated, yield a considerable quantity of alcohol.

II. *Ardent spirits or whiskey from fecula or starchy materials.*

I have already pointed out, in the article BEER, how the starch is transformed into a saccharine condition, by malting and mashing; and how a fermentable wort may be obtained from starchy meal. By like operations may all vegetable substances, which consist chiefly of starch, become materials for a whiskey distillery. To this class belong all the farinaceous grains, potatoes, and the pods of shell fruits, as beans, vetches, horse-chestnuts, acorns, &c.

1. *Whiskey from corn.* All those species of corn which are employed in breweries answer for distilleries; as wheat, rye, barley, and oats; as well as buckwheat, and maize or Indian corn. The product of spirits which these different grains afford, depends upon the proportion of starch they contain, including the small quantity of uncrystallizable sugar present in them. Hermstaedt, who has made exact experiments upon the subject, reckons a quart (Prussian or British) of spirits, containing 30 per cent. of the absolute alcohol of Richter, for 2 pounds of starch. Hence 100 pounds of starch should yield

.cohol; or 4·375 gallons imperial, equal to 7·8 gallons of spirits, excise

f the following grains afford in spirits of specific gravity 0.9427, con-
cent. of absolute alcohol, (= $\frac{9}{11}$ of British proof,) the following quan-

, 45 pounds of spirits; rye, 36 to 42; barley, 40; oats, 36; buckwheat,
The mean of the whole may be taken at 40 pounds, equal to 4¼ gallons
127 specific gravity = 3·47 gallons, at excise proof. The chief difference
kinds of corn consists in their different bulks under the same weight; a
lerable importance; for since a bushel of oats weighs little more than the
l of wheat, the former becomes for some purposes less convenient in use
though it affords a good spirit.
ye are the species of grain most commonly employed in the European
naking whiskey. Barley is mostly taken either partly or altogether in
; while the other corns are not malted, but merely mixed with a certain
rley malt to favor the saccharine fermentation in the mashing. It is
)le to use a mixture of several sorts of grain, instead of a single one; for
with barley and oats; or barley with rye and wheat; for the husks of
d through the wheat flour and rye meal keep it open or porous when
is favor the abstraction of the wort; while the gluten of the wheat tends
starch of the barley and oats into sugar. When the whole of the grain,
lted, a much more limpid wort is obtained than from a mixture of malt
; hence the pure malt is preferable for the ale and porter brewer, while
rds a larger product, at the same cost of materials, to the distiller. When
aly grain employed, from one third to one sixth of malt is usually mixed
en wheat and rye are also taken, the addition of from one eighth to one
·ley malt is sufficient. Oats are peculiarly proper to be mixed with wheat,
d open in the mashing.
are the proportions used by some experienced Scotch distillers.
, containing 6 bushels each, being used for a mashing, consist of,

 of oats, weighing 284 lbs. per boll, or 47½ lbs. per bushel;

malt	240	40
rye	320	53½
barley	320	53½
		mean 48½

oll, weighing 291 lbs., 14 imperial gallons of proof whiskey are obtained
equivalent to 11·2 gallons at 25 over proof.
for the distilleries is to be conducted on the same principles as for the
he malt ought to be lightly kiln-dried, and that preferably at a steam heat,
, which is apt to give an empyreumatic smell to the grain that passes into
r such persons, indeed, as relish the smell of burned turf, called peat-reek
malt should be dried by a turf fire, whereby the whiskey will acquire
or.
l, which was originally prized as a criterion of whiskey made from pure
y fermented and distilled with peculiar care, has of late years lost its
artifice of impregnating bad raw grain whiskey with peat-smoke has been
:tised.
his treatise on making spirits, describes a malting kiln with a copper
th steam, 18 feet long, and 12 feet broad, on which a quantity of malt
in, is changed every 3 or 4 hours, so that in 24 hours he turns out upwards
excellent and well kilned article. The malt of the distiller should be as
, because with the deepening of the color an empyreumatic principle is

corn is the subject of distillation, it must be malted in the same way as
e article BEER. According to Hermstaedt, its flour may be advan-
 with the crushed malt in the mash tun. But its more complete dissolu-
:omplished by Siemen's mode of operating upon potatoes, presently to be

Barley and raw grain are ground to meal by millstones, but malt is merely
n rollers. If only one tenth or one eighth of malt be used with nine
 eighths of barley, some husks of oats are added, to render the mash
rainable.
shels of barley and 20 of malt form one mashing, from 600 to 700
r, heated to 150° F., are mixed with these 60 bushels in the mash tun,

and carefully incorporated by much manual labor with wooden oars, or in great concerns by the mechanical apparatus used in the breweries. This agitation must be continued for 2 or 3 hours, with the admission from time to time of about 400 additional gallons of water, at a temperature of 190°, to counteract the cooling of the materials. But since the discovery of *diastase*, as the best heat for saccharifying starch is shown to be not higher than 160° F., it would be far better to mash in a tun, partially, at least, steam incased, whereby we could preserve the temperature at the appropriate degree for generating the greatest quantity of sugar.

If the wort be examined every half-hour of the mashing period, it will be found to become progressively sweeter to the taste, thinner in appearance, but denser in reality.

The wort must be drawn off from the grains whenever it has attained its maximum density, which seldom exceeds 150 lbs. per barrel; that is, $\dfrac{360 + 150}{360} = 1.42$, or 42 per cent. As the corn of the distiller of raw grain has not the same porosity as the brewer's, the wort cannot be drawn off from the bottom of the tun, but through a series of holes at the level of the liquor, bored in a pipe stuck in at the corner of the vessel. About one third only of the water of infusion can thus be drawn off from the pasty mass. More water is therefore poured on at the temperature of 190°, well mixed by agitation for half an hour, then quietly infused for an hour and a half, and finally drawn off as before. Fully 400 gallons of water are used upon this occasion, and nearly as much liquor may be drawn off. Lastly, to extract from the grains everything soluble, about 700 gallons of boiling hot water are turned in upon them, thoroughly incorporated, then left quietly to infuse, and drawn off as above. This weak wort is commonly reserved for the first liquor of the next mashing operation upon a fresh quantity of meal and malt.

The English distiller is bound by law to make his mixed worts to be let down into the fermenting tun of a specific gravity not less than 1·050, nor more than 1 090; the Scotch and Irish distillers not less than 1·030, nor more than 1·080; which numbers are called, gravity 50, 90, 30, and 80, respectively.

With the proportion of malt, raw grain, and water, above prescribed, the infusion first drawn off may have a strength = 20 per cent. = spec. grav. 1·082, or 73 lbs. per barrel; the second of 50 lbs. per barrel, or 14 per cent.; and the two together would have a strength of 61·2 lbs. per barrel = 17 per cent., or spec. grav. 1·070. From experiments carefully made upon a considerable scale, it appears that no more than four fifths of the soluble saccharo-starchy matter of the worts is decomposed in the best regulated fermentations of the distiller from raw grain. For every 2 lbs. so decomposed, 1 lb. of alcohol, spec. grav. 0·825, is generated; and as every gallon of spirits of the spec. grav. 0·909 contains 4·6 lbs. of such alcohol, it will take twice 4·6 or 9·2 lbs. of saccharine matter to produce the said gallon. To these 9·2 lbs., truly transmuted in the process, we must add one fifth, or 1·84 lbs., which will raise to 11·04 the amount of solid matter employed in producing a gallon of the above spirits.

Some distillers mash a fourth time; and always use the feeble wort so obtained in mashing fresh grain.

2. As the imperfect saccharine infusion obtained from raw grain is much more accescent than the rich sugary solution got from malt in the breweries, the distiller must use every precaution to cool his worts as quickly as possible, and to keep them clear from any acetous taint. The different schemes of cooling worts are considered under BEER and REFRIGERATION. As the worts cool, a quantity of starchy matter is precipitated, but it is all carefully swept along into the fermenting tun, and undoubtedly contributes to increase the production of alcohol. During the winter and temperate months, when the distilleries are most actively at work, the temperature at which the worts are set is usually about 70° F. When much farinaceous deposite is present, the heat may be only 65°, because, in this case, a slow fermentation seems to favor the conversion of that starch into sugar. In some German distilleries a little chalk is mixed with the worts, to check acidity.

3. *The fermentation.*

The yeast added to the worts as a ferment, ought to be the best top barm of the London porter breweries. About 1 gallon of it is requisite for every 2 bushels of meal and malt worked up in the mashing process; and of this quantity only a certain proportion is introduced at the beginning; the remainder being added by degrees, on the second and third days.

Should the fermentation flag, a little more may be added on the fourth or fifth day, and the contents of the tun may be roused by an agitator. About 8 or 9 gallons may be introduced four days in succession to the quantity of worts extracted from 60 bushels of the farinaceous materials; or the third day's dose may be intermitted, and joined to the fourth on the subsequent day.

Great diversity and no little caprice prevail among distillers in respect of the periods of administering the yeast; but they should be governed very much by the appearance of the fermentation. This process continues from nine to twelve or even fourteen days, according to circumstances; the tuns being left quite open during the first five days, but being covered moderately close afterwards to favour the full impregnation of the liquor with carbonic acid, as a fermenting .agent. In consequence of the great attenuation of the wort by the generation of so much alcohol, no good body of yeast continues to float on the surface, and what is formed is beat down into the liquor on purpose to promote the fermentation. The temperature of the wash gradually increases till towards the end of the fourth day, when it attains its maximum height of about 25° above the pitch of 55° or 60° at which it may have been set. The time of the greatest elevation of temperature, as well as its amount, depends conjointly upon the quality of the yeast, the nature of the saccharo-starchy matter, and the state of the weather. It is highly probable that the electrical condition of the atmosphere exercises a considerable influence upon fermentation. We know the power of a thunder-storm to sour vinous fluids. An experimental inquiry into the relation between electricity and fermentation, could not fail to prove both curious and profitable.

The dimunition of the density of the wort is carefully watched by the distiller, as the true criterion of the success of his process. This *attenuation*, as he calls it, is owing partly to the decomposition of the sugar, which communicated its gravity to the solution, and partly to the introduction of the lighter alcoholic particles. Were all the saccharo-starchy matter resolved into gaseous compounds, the wort would become water; but since a part of it remains undecomposed, and a portion of alcohol is produced at the expense of the decomposed part, the degree of attenuation becomes a somewhat complicated problem in a theoretical point of view; the density due to the residuary sugar being masked and counteracted by the spirit evolved. Could the alcohol be drawn off as it is formed, the attenuation would probably become greater, because the alcohol checks the fermentative action, and eventually stops it, before all the saccharum is decomposed. After the wash has taken its highest degree of temperature, not much more spirit is found to be generated; were this therefore removed by proper means, the remaining vegetable matter would undoubtedly yield a further product of alcohol.

In the attenuation of raw-grain wash, the specific gravity seldom arrives at 1·000; but most commonly stops short at 1·002 or 1·004. When the vinous fermentation comes to an end, the acetous is apt to commence, and to convert a portion of the alcohol into vinegar; a result which is easily ascertained by the increasing specific gravity, sour smell, and acidulous reaction of the wash upon litmus paper, which remains after the paper is heated, showing that the red color is not caused by carbonic acid.

Fermentation proceeds with more uniformity and success in the large tuns of the distiller, than in the experimental apparatus of the chemist; because the body of heat generated in the former case maintains the action. But I have succeeded in obviating this inconvenience in operating upon 80 or 90 gallons, by keeping up the temperature, when it begins to flag, by transmitting hot water through a recurved pipe plunged into the tun.

We have already mentioned that one gallon of spirits, one in ten over-proof, is upon the average generated from 11·04 lbs. of starch sugar; hence we conclude that one pound water-measure of spirits at proof ($= \frac{1}{10}$ imperial gallon) is produced from one pound of the saccharum.

Malt whiskey.—The treatment and produce of malt distilleries are in some respects different from those of raw grain. Having been professionally employed by the proprietors of both, I am prepared to state the peculiarities of the latter, by an example. 500 bushels of ground malt are first mashed with 9000 gallons of water, heated to the temperature of 160° F.: 6000 gallons of worts are drawn off into the coolers, and let down into the fermenting tun at 68°. From 3 to 4 per cent. of a mixture of London porter yeast with quick Scotch barm are added, and well stirred through the mass. At the end of two or three days, in general, the fermentation is finished. On the residuary grains of the malt, from 4500 to 5000 gallons of water at 180° are run, which after proper mashing as before, are drawn off; then 4500 more are poured on, the drainage of which is added to the second. Both of these together, constituting 9000 gallons, are heated next day, and employed for the mashing of 500 bushels of fresh malt. During the fermentation, the wash which was set at the spec. grav. 1·065, comes down to water = 1·000.

The wash is distilled in two stills, appropriated to it, of about 800 gallons capacity each, provided with a rotatory chain apparatus for preventing the lees from adhering to the bottom of the still. Into about 800 gallons of wash 8 lbs. of soap are put. The liquor obtained at this first distillation is called low wines. These low wines are redistilled in the spirit stills; the first and last portions of liquid being more or less blue or milky in color, and rank in flavor, are run into a separate receiver called the *faints-back;*

while the middle portion, constituting in a well-managed distillery, from three fourths to four fifths of the whole, are received into the spirit-back. The faints are mixed with a large quantity of water, and redistilled, in order to free them from the fetid oil derived from the husks of the grain. The interception of this noxious oil may be best effected by a self-regulating bath, between the capital of the still and the refrigeratory, as will be explained in treating of STILLS. The capitals of the common Scotch stills are made from 15 to 20 feet high, in order to prevent the chance of the wash boiling over into the worm; and they are, towards the beginning of the process, struck from time to time with a rod, and by the sound emitted it is known whether they be empty, partially filled, or in danger of an overflow; in which case the fire is damped, by a spout near the furnace door, connected by a leather pipe with an elevated reservoir of water. When very pure spirits are wished for, a third or even a fourth distillation is had recourse to; there being a quantity of water mixed each time with the spirit in the still, to prevent its acquiring a harsh alcoholic flavor.

According to some experienced distillers from raw grain, the mashing temperature of the first liquor should not exceed 140° F.; whereas with malt it may be safely and beneficially 165° or 170°. When rye is used instead of malt, 90 bushels of it are mixed with 190 bushels of raw grain, constituting 280 bushels in whole, for the mashing of which 5200 gallons of water are required. An hour and a half more time is necessary for settling the mashing of the above mixture, than of grain alone. Gin is made in this way.

The distiller of malt whiskey calculates on obtaining two gallons of proof spirits from one bushel of malt, in average years. The highest yield is 20 gallons per quarter of 8 bushels; and the lowest is 16, when the malt and fermentation are indifferent. The best temperature to set the fermenting tun with malt wash is about 70° or 72° F.

When malt is 5s. the bushel, 6 bushels at 30s. will yield 12 gallons of proof spirits. These cost therefore 2s. 6d. per gallon for the malt; to which must be added 3d. per bushel for the amount of malt duty not returned, or 1½d. on the gallon; this added to the Scotch duty of 3s. 4d. the gallon, makes the price altogether 5s. 11½d.; besides the expenses in fuel, yeast, labor, and rent, which may be estimated at 8½d. per gallon. But 3d. may be deducted for what is paid by the dairymen for the spent wash and grains. The total cost, therefore, exclusive of use of capital, is 6s. 5d. per gallon in Scotland.

The following is the work of a Scotch distillery, where good malt whiskey was made.

One bushel of the malt weighed 35 lbs., or the boll, = 6 bushels, 210 lbs. In mashing each boll of malt, 110 gallons of water were run on it at 160° F. As soon as the fermenting tun of 3000 gallons capacity was charged with the wash at from 64° to 74° F., 2 gallons per cent. of barm were added. When the wash had become attenuated from 1·060 to 1·040, another gallon of barm was introduced.

The temperature of the fermenting wash sometimes rises to 96°, which is, however, an extreme case, and not desirable. When the bubbles of carbonic acid mount in rapid succession, it is reckoned an excellent sign. If the tun be small, and stand in a cool apartment, it should be started at a higher temperature than in the reverse predicament. Should the fermentation be suffered to flag, it is in general a hopeless task to restore vigorous action. Some try the addition of bubs, that is, of some wort brought into a state of rapid fermentation in a tub, by a large proportion of yeast, but seldom with much success. Indeed, the law prohibits the addition of any wort to the tun at a later period than 24 hours after it is set; so that if bubs are used afterwards, the distiller is apt to incur a penalty.

The maximum quantity of proof spirits obtained on the great scale at any time from raw grain mixed with from one fourth to one eighth of malt, seems to be 22 gallons per quarter.

By the British laws a distiller is not allowed to brew and distil at the same time; but he must work alternately, one week, for instance, at fermentation, and next week at distillation.

In fermenting solutions of sugar mixed with good yeast, the attenuation has been carried down to 0·984, and even 0·982, that is, in the language of the excise, 16 and 18 degrees below water, from 1·060, the density at which it was originally set in the tun. This was excellent work done on the scale of a great distillery nearly 30 years ago, when distillation from sugar was encouraged, in consequence of bad corn harvests.

In an experiment which I made in 1831, for the information of a committee of the House of Commons, on the use of molasses in the breweries and distilleries, I dissolved 1 cwt. of raw sugar in water, so as to form 74½ gallons, inclusive of 2 gallons of yeast. The specific gravity of the mixture was 1·0593 on the 31st of March. By the 6th of April, that is, in 6 days, the gravity had sunk to 0·992, or 8 degrees under water, which was reckoned a good attenuation, considering the circumstances and the small quantity operated upon. By distillation it afforded at the rate of 14·875 gallons of proof spirits for 100 gallons of the wash.

When the distillers first worked from sugar, they only obtained upon an average from 1 cwt. 10·09 gallons imp. of proof spirit; but they afterwards got no less than 11·92 imp. gallons.

The following experiment, which I made upon the fermentation of West India molasses into spirits, for the information of the said committee, may prove not uninteresting to my readers. 150 lbs. were dissolved in water and mixed with 2 gallons of yeast, weighing exactly 20 lbs. The wash measured 70 gallons, and had a spec. gravity of 1·0647 at 60° F. In two days the gravity had fallen to 1·0055; in three days to 1·0022; and in five days to 1·001. The temperature was kept up at from 80° to 90° F., during the last two days, by means of a steam pipe, to favor the fermentation. The product of spirits was 11 gallons, and $\frac{35}{100}$ of a gallon. Now 150 lbs. of the above molasses were found to contain of solid matter, chiefly uncrystallizable, 112 lbs. And as 112 lbs. of sugar are estimated by the revenue laws to afford by fermentation 11½ gallons imp. of proof spirit, the result of that experiment upon molasses must be considered satisfactory, bearing in mind that the saccharine substance in molasses has been not only partially decomposed by heat, but is mixed with some of the glutinous or extractive matter of the cane.

Since the alteration of the excise laws relative to distillation in 1825 and 1826, when permission was given to set the wort at lower gravities, the quantity of spirits produced from 1 quarter of corn has been much increased, even up to fully 20 gallons; and the proportion of malt has been much diminished. The latter was soon reduced from three sevenths malt, and four sevenths barley, or two fifths malt and three fifths barley, to one fifth of malt and now to one tenth or even one sixteenth.

A discussion having lately taken place in Ireland between certain persons connected with the distilleries and the officers of the excise, whether, and to what extent, raw grain worts would pass spontaneously into the vinous fermentation, the Board in London requested me to superintend a series of researches in a laboratory fitted up at their office, to settle this important point. I shall content myself here with giving the result of one experiment, out of several, which seems to me quite decisive. Three bushels of mixed grains were taken, consisting of two of barley, one half of oats, and one half of malt, which, being coarsely ground by a hand-mill, were mashed in a new tun with 24 gallons of water at 155°. The mash liquor drawn off amounted to 18 gallons, at the density of 1·0465; and temperature of 82° F. Being set in a new tun, it began to ferment in the course of 12 hours, and in 4 days it was attenuated down to gravity 1·012. This yielded, upon distillation in low wines, 3·22 gallons, and by rectification, in spirits, 3·05; while the quantity equivalent to the attenuation by the tables was 3·31, being an excellent accordance in such circumstances.

The inquisitorial *régime* imposed by law upon our distilleries, might lead a stranger to imagine that our legislators were desirous of repressing by every species of annoyance the fabrication of the fiery liquid which infuriates and demoralizes the lower population of these islands. But alas! credit can be given them for no such moral or philanthropic motive. The necessity of the exchequer to raise a great revenue, created by the wasteful expenditure of the state, on the one hand, and the efforts of fraudulent ingenuity on the other, to evade the payment of the high duties imposed, are the true origin of that *régime*. Examinations in distilleries are constantly making by the officers of excise. There is a survey at 6 o'clock in the morning, when the officers take their accounts and gauges, and make calculations which occupy several hours. At 10 o'clock they again survey, going over the whole premises, where they continue a considerable time, frequently till the succeeding officer comes on duty; at 2 in the afternoon another survey takes place, but not by the same people; at 6 in the evening the survey is repeated; at 10 there comes another survey by an officer who had not been engaged in any of the previous surveys of that day. He is not relieved till 6 o'clock next morning. In addition to these regular inspections, the distilleries are subject to frequent and uncertain visits of the surveyor and general surveyor. "We are never," says Mr. Smith, the eminent distiller of Whitechapel, "out of their hands."[*]

Before the fermented wort goes into the still, a calculation is made of the quantity of wash drawn from the wash back, and which is first pumped into what is called the wash charger. If the quantity in the wash charger exceeds the quantity in the wash back, the distiller is charged upon the higher quantity; if it contains less, he must pay according to the wash back, as being the larger quantity. When the quantity of wash is all transferred to the charger, the discharge cock of the wash charger is unlocked, and the wash is allowed to be drawn off from the charger into the still, the charging and discharging cock of the still being locked by the officer. There can be no transfer of wash but through the pumps, which are locked also. The first distillation from the wash is worked into the low-wine receiver, which is also a locked up vessel; then of

those low wines, the strength and quantity are ascertained by the excise. The account of them affords a comparison with the quantity which the contents of the wash-back had been estimated to produce; they are then pumped from the low wine receiver, through pumps previously locked into the low wine charger, which is also a locked up vessel; from the locked up charger, after the officer has done his duty regarding it, they are allowed to be drawn off into the low wine still, which is a distillation of the second extraction; then that low wine still works into another locked up cask, called the spirit receiver, for the receiving of raw spirits; when that distillation is finished, the officer, attending again on regular notice for that purpose, takes the quantity and strength of the spirits therein, and upon the quantity so ascertained he charges the duty. In distilling low wines, one portion of them goes into the spirit receiver, and a portion into what is called the faint receiver, which is another locked up vessel. These faints are in the next distillation united with the low wines, from the succeeding wash-back on their second distillation, and are worked together; the united produce of these goes partly into the spirit cask, and partly back again into the faint cask. The operation is thus continued till all the backs in the house are emptied.*

There is a kind of ardent spirits manufactured in Holland, vulgarly called Dutch gin, Hollands, and sometimes geneva, from genievre, the French for juniper, a plant with the essential oil of whose berries it is flavored. One cwt. of ground malt mixed with two cwts. of rye meal are mashed for two hours, with about 450 gallons of water at the temperature of 160° F. The mash drawn off is reduced with cold water till the liquid just has the density of 45 lbs. per barrel, = specific gravity 1·047; and is then put all together into the fermenting back at the temperature of 80° F. One or two gallons of yeast are added. The fermentation soon becomes so vigorous as to raise the heat to 90° and upwards, but it is not pushed far, being generally over in two days, when the gravity of the wash still indicates 12 pounds of saccharum per barrel. By this moderate attenuation, like that practised by the contraband distillers of the Highlands of Scotland, it is supposed that the fetid oil of the husks is not evolved, or at least in very small quantity. The grains are put into the alembic along with the liquid wash, and distilled into low wine, which are rectified twice over, some juniper berries and hops being added at the last distillation. But the junipers are sometimes bruised and put into the mash. The produce of worts so imperfectly fermented, is probably little more than one half of what the British distiller draws from the same quantity of grain. But the cheapness of labor and of grain, as well as the superior flavor of the Skiedam spirits, enables the Dutch distiller to carry on his business with a respectable profit. In opposition to the above facts, Dubrunfaut says that about one third more spirits is obtained in Holland from grain than in France, because a very calcareous spring water is employed in the mashing operation. Were this account well founded, all that the distillers of other countries would have to do would be merely to introduce a portion of chalk into their mash tuns, in order to be on a par with the Dutch. But the statement is altogether a mistake.

In the vine countries, the inferior wines or those damaged by keeping, as also a fermented mash of the pressed grapes, mixed with water, are distilled to form the eau de vie de Cognac of the French, called Brandy in this country. It contains less essential oil, and that of a more agreeable flavor, than corn spirits. See BRANDY.

Berzelius says that there are distillers who are guilty of putting a little arsenious acid into the still; that the spirits contain pretty frequently traces of arsenic, which may be detected by adding to them a little muriatic acid, then evaporating off the alcohol, and passing a current of sulphureted hydrogen gas through the residuary liquid, which will give it the characteristic orpiment yellow tinge, arsenic being present. Copper, which is sometimes introduced into distilled grain, or even malt spirits, in consequence of the soap employed in the process of distillation, may be detected best by the brown precipitate which it occasions with ferroprussiate of potash. No arsca c is ever used in this country.

When damaged grain has been mashed in making whiskey, a peculiar oily substance makes its appearance in it. On approaching the nostrils to such whiskey slightly heated, this volatile matter irritates the pituitary membrane and the eyes very powerfully. These spirits have exactly the smell of an alcoholic solution of cyanogene; they intoxicate more powerfully than pure alcohol of equal strength, and produce even temporary phrensy, with subsequent sickness and disordered functions. This volatile body is not cyanogene, though it be so like it, for it forms no such combinations as cyanogene does. It may be extracted from diluted alcohol by agitating it with an unctuous oil, and then distilling the oil along with water. At the end of 3 or 4 months, this volatile matter disappears in a great measure, even when the spirits impregnated with it are enclosed in well-corked bottles; obviously from its undergoing a spontaneous decomposition. It may be preserved much longer in the state of a watery solution.

When acetic ether is added to well purified or clean spirits, such as the distillers call

silent whiskey, it gives it somewhat of the flavor of brandy. For this purpose, also, the spirits are rectified from bruised prunes, or the lees of the cognac distilleries, whereby they acquire additional flavor. The astringent taste of old brandy is imitated by the introduction of a little catechu into the British spirits. Burned sugar is employed as a coloring in these imitations.

IV. *Of making whiskey from potatoes.*—This root, in certain localities where it abounds at a moderate price, is an excellent material for fermenting into alcohol. When sound, it possesses from 20 to 25 per cent. of solid substance, of which starch constitutes at least three fourths; hence 100 pounds contain from 16 to 22 pounds of starch susceptible of being saccharified. In the expressed juice there is a small quantity of tartaric acid.

Previously to mashing, potatoes must be first well washed in a horizontal cylindrical cage revolving partially in a trough of water, as will be described in treating of the manufacture of sugar from beet root. They must be then boiled in a close vessel with steam, provided with a perforated bottom a few inches above the real one. The top has an opening with a cover fitted tightly to it; through that the potatoes are introduced; and immediately above the false bottom there is a similar aperture through which the boiled potatoes are taken out. The steam-pipe enters at the top, runs down the side a little way, and terminates in a widened mouth. The large lids are secured by cross bars, the small hole by folds of linen. In the lower valve there are two small holes closed with pins, for inserting a wire to feel whether the potatoes be sufficiently boiled. If so, the steam is immediately stopped off, the lower lid is removed, and the potatoes

pulled out with a hook into a tub. They must be immediately made into a homogeneous paste before they get cold. *Fig.* 361 represents, in plan, or horizontal section, the apparatus used in France for this purpose. A B are two cylinders covered with wire cloth, but open at the ends; C C and D D are two pieces of wood fixed on the two axes, in the form of two cones, with the adjoining surfaces truncated; upon which, as also upon iron rings E F, of the same diameter, made fast to the axes, the wire cylinder rests. Of the two wheels G H, the smaller has 18, the greater has 21 teeth. The diameter of each cylinder is 14 inches, the length 18. Above and between the two cylinders, there is a hopper for the reception of the boiled potatoes. This machine triturates 1200 pounds of potatoes per hour. Their paste must be forthwith mashed with some ground wheat or barley, and a proportion of malt; then be set a fermenting.
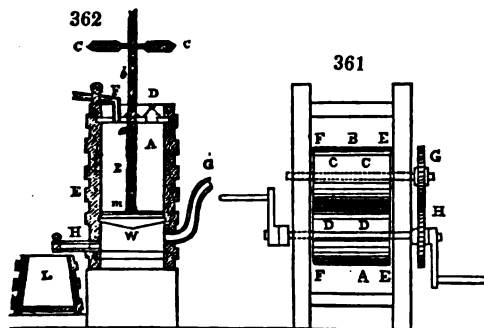
As in the above mode of trituration, the potatoes are apt to cool to such a degree as to obstruct their ready admixture with water, it is better to make them into a paste in the vessel in which they are steamed. The apparatus contrived by Siemens fully answers this end. It consists essentially of a tub A, represented in *fig.* 362, in section. It is cylindrical, and made of planks from 3 to 4 inches thick, joined firmly and steam-tight; the upper and under ends being well secured with iron hoops. The lower part is about 2 inches more in diameter than the upper. About a foot from the bottom, in a circular groove, a cast iron partition w, or disc full of holes, is made fast, which serves the purpose of a searce, the apertures being an inch asunder; above, from $\frac{1}{8}$ to $\frac{1}{10}$ of an inch in diameter, and below, scooped out to half an inch. This disc is half an inch thick in the edges, and five fourths of an inch in the middle.

Through the female screw a in the top of the cylinder, there passes the screwed rod b, one and a half inches thick, provided at top with a strong cross bar c c, for turning it round. The under end of this rod has a square piece terminating in a short screw, upon which a wrought iron cross is secured by means of a screw nut, so as to stand at right angles to the rod. This cross is composed of two distinct arms; of which one of them is mounted on the upper side with little knives an inch and a half long; the other, upon the under side, with a wire brush, that may be made to rub against the perforated cast iron disc. On the side of the cylinder at E, *fig.* 362, there is a narrow aperture provided with a bung secured by a cross bar, and near the bottom at H there is another like it. Both openings serve for taking out the residuary matter. Through the opening E, the above two arms are introduced; and secured to the square of the rod by the screw nut. In the top there is an opening, D,

for putting in the potatoes which may be shut in the same way. From the lid there likewise issues a lateral tube F, which terminates in a tubful of water, for condensing the waste steam. G is the tube connected with the steam boiler, for conducting the steam into the space under the iron disc w.

With this apparatus the potatoes are prepared as follows: when the screw rod is so fixed that the cross touches the disc, the cylinder is to be filled with washed potatoes to within one foot of the top, leaving them some space to expand. The orifice D is to be then closed, and the steam admitted. When the potatoes are boiled enough, two laborers lay hold of the lever handles c c, of the screw rod b, and turn it round with the effect of screwing up the spiked cross, and of triturating the potatoes; an operation which may be still more effectually done by screwing it down again. The potato paste is now let off by the plug hole H, into the tub L, where it is mixed with about 30 per cent. of boiling water, and one thousandth part of potash, made caustic with quicklime, in order to dissolve the albuminous matter coagulated by the heat, and give complete fluidity to the mass. The alkali also neutralizes the tartaric acid present. The mashed matter must now be mixed with the crushed malt diffused through 40 or 50 pounds of cold water for every 100 pounds of potatoes, which lowers the temperature to 167°. The wort must be then diligently stirred during two hours; mixed with 40 or 50 pounds of cold water for 100 pounds of potatoes, and, when reduced to the temperature of 77°, put into the fermenting tun along with the proper quantity (3 or 4 per cent.) of yeast. As potatoes readily pass into the acetous fermentation, the admixture of the malt, the mashing, and the cooling should be rapidly performed, while the utmost cleanliness must be observed.

The fermentation is brisk, probably from the agency of the albumen, and furnishes a good head of barm, which answers well for the bakers; 100 pounds of potatoes yield from 18 to 20 pounds measure of spirits, nine elevenths of our excise proof; or about 16 pounds measure of proof, = about 1¾ gallons.

It has been observed that after the month of December potatoes begin to yield a smaller product of fermented spirits; and when they have once sprouted or germinated, they afford very little indeed. From the difficulty of keeping and transporting potatoes, distillation from them, even though our laws now permit it, can never become general till some plan be adopted for overcoming these disadvantages. A scheme of this kind, however, has been successfully practised in Vienna, which consists in subjecting the washed potatoes to strong pressure in a perforated chest by a hydraulic or screw press, whereby they lose about three fourths of their weight, and may then be readily dried into a white flour, that may be kept for several years without injury, and transported to considerable distances with comparative ease. This flour, mixed with a moderate quantity of ground malt, and saccharified by mashing with water, at the temperature of 167° F., becomes capable of affording a sweet wort convertible by fermentation either into beer or whiskey.

Horse-chestnuts, according to Hermstaedt, are an eligible material for producing alcohol, as 128 pounds of them afford 100 pounds of meal; which 100 pounds yield, by proper treatment, 34 pounds of spirits, containing 36 per cent. of absolute alcohol, by Richter's tables. Barley to the extent of 10 pounds per 100 should be ground up with them, after they have been boiled in a steam apparatus, not only for the purpose of softening them, but freeing them from their bitter astringent matter. Acorns are productive of alcohol by similar treatment.

The best means hitherto discovered for depriving bad whiskey of its nauseous smell and taste is to pass it through well burned and coarsely pulverized charcoal, distributed as follows in a series of cylindrical casks. Each vessel must have a double bottom, the false one being perforated with conical holes, and placed a few inches above the true. Upon this perforated board a layer of chopped clean straw, one inch thick, is laid; and over the straw, a stratum of small river gravel, the size of large peas. This is to be covered with a pretty thick stratum of the charcoal, previously freed from dirt and dust by washing; upon which a piece of close canvass is to be spread, and pressed down by a thin bed of river sand. The cylinder or cask should be filled with these successive layers to within two inches of its top, and it is then to be closed air-tight. Immediately below the head, a round orifice is pierced in the side, for receiving an overflow tube, which is either screwed rectangularly to another elbow pipe, or is bent (when of block tin) so as to enter tight into an orifice beneath the false bottom of the second cylinder or cask. In this way, the series may be continued to any desired number of vessels; the last discharging the purified spirit into the store-back. The foul spirit must be made to flow into the bottom space of the first cylinder down through a pipe in communication with a charging-back placed upon such an elevated level as to give sufficient pressure to force the spirits up through the series of filters; the supply-pipe being provided with a regulating stop-cock. The spirit may be filtered *downwards* through sand and cloth in

assage to the receiver. It has been found, with very crude spirits, that eight
e cylinders were required to deprive them entirely of the rank flavor.

year 1831, 23,000,000 gallons of spirits were made in the United Kingdom,
it to the consumption of 1,500,000 quarters of grain, and for that year and the
ceding years, there were imported annually 2,000,000 of quarters of foreign

In 1832, 20,778,521 gallons paid excise duty.
1834, 23,397,806.
1836, 27,137,000 ; of which 14,000,000 were Irish.

iy add to the last quantity, 3 millions of gallons at least on the score of smug-
licensed and illicit distilleries ; making 30 millions to be the frightful amount
·y consumed by the British people, independent of other intoxicating liquors.

MACY, from the Greek Δοκιμαζω, I prove (Docimasie, Fr.; Probierkunst,
is the art by which the nature and proportions of an ore are determined.
dytical examination was originally conducted in the dry way, the metal being
from its mineralizers, by means of heat and certain fluxes. But this method
ntually found to be insufficient and even fallacious, especially when volatile
ere in question, or when the fluxes could absorb them. The latter circum-
·came a very serious evil, whenever the object was to appreciate an ore that was
·rked at great expense. Bergmann first demonstrated, in an elaborate disser-
at the humid analysis was much to be preferred ; and since his time the dry
. been consecrated chiefly to the direction of metallurgic operations, or, at
has been employed merely in concert with the humid, in trials upon the
le.

discovering an ore of some valuable metal, it is essential to ascertain if its
and state of combination will justify an adventurer in working the mine, and
its products. The metal is rarely found in a condition approaching to purity;
1 disseminated in a mineralizing gangue far more bulky than itself; and more
y still it is combined with simple non-metallic substances, such as sulphur,
:hlorine, oxygen, and acids, more or less difficult to get rid of. In these
d states its distinctive characters are so altered, that it is not an easy task
· recognise its nature, or to decide if it can be smelted with advantage. The
without neglecting any of the external characters of the ore, seeks to penetrate,
ak, into its interior ; he triturates it to an impalpable powder, and then subjects
decomposing action of powerful chemical reagents; sometimes with the aid of
ir salts appropriate to its nature, he employs the dry way by fire alone; at
e calls in the solvent power of acids with a digesting heat; happy, if after a
· labors, long, varied, and intricate, he shall finally succeed in separating a
proportion of one or more metals either in a pure state, or in a form of com-
such, that from the amount of this known compound, he can infer, with
, the quantity of fine metal, and thereby the probable value of the mine. The
e, skilfully applied, affords ready indications of the nature of the metallic
·nts, and is therefore usually the preliminary test. The separation of the
constituents of the ore can be effected, however, only by a chemist, who joins
1ost extensive knowledge of the habitudes of mineral substances, much expe-
agacity, and precision, in the conduct of analytical operations. Under the
il metals, as also in the articles METALLURGY, MINES, and ORES, I have endea-
present such a copious and correct detail of docimastic processes, as will
guide the intelligent student through this most mysterious labyrinth of nature

/OCK is a species of figured linen of stout fabric, which derives its name
own in Scotland, where it was first manufactured for table-cloths. It is the
ple in pattern of all the varieties of the diaper or damask style, and therefore
s are usually of coarse quality for common household wear. It receives the
· reversing the flushing of the warp and woof at certain intervals, so as to form
or oblong rectangles upon the cloth. The most simple of these is a succession
ate squares, forming an imitation of a checker board or mosaic work. The
kinds are generally woven as tweels of three leaves, where every thread floats
>, and is intersected by the third in succession. Some of the finer are tweels
ir five leaves, but few of more; for the six and seven leaf tweels are seldom or
sed, and the eight leaf tweel is confined almost exclusively to damask. See
: FABRIC.

GON'S BLOOD (Sang dracon, Fr.; Drachenblut, Germ.) is a resinous
e, which comes to us sometimes in small balls of the size of a pigeon's egg,
s in rods, like the finger, and sometimes in irregular cakes. Its color, in
dark brown red; in powder, bright red; friable; of a shining fracture,
r. 1·196. It contains a little benzoic acid, is insoluble in water, but dissolves

readily in alcohol, ether, and oils. It is brought from the East Indies, Africa, South America, as the produce of several trees, the *Dracæna Draco*, the *Pterocarpus santalinus*, the *Pterocarpus Draco*, and the *Calamus Rotang*.

Dragon's blood is used chiefly for tingeing spirit and turpentine varnishes, for preparing gold lacker, for tooth tinctures and powders, for staining marble, &c. According to Herbenger, it consists of 9·07 parts of red resin, 2 of fat oil, 3 of benzoic acid, 1·6 of oxalate, and 3·7 of phosphate of lime.

DRUGGET is a coarse, but rather slight, woollen fabric, used for covering carpets, and as an article of clothing by females of the poorer classes. It is now-a-days nearly superseded by coarse cotton goods.

DRYING HOUSE. An apartment fitted up in a peculiar manner for drying calicoes, and other textile fabrics. Mr. Southworth, of Sharples, a Lancashire bleacher, obtained a patent, in 1823, for the following ingenious arrangement, which has been since generally adopted, with certain modifications, in most of our extensive bleaching and printing works. *Fig.* 363 is a section of the drying-house, where *a* is a furnace and
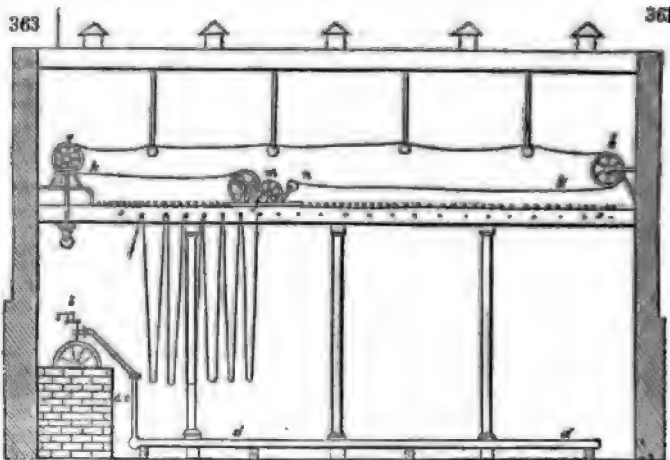
boiler for the purpose of generating steam; it is furnished with a safety valve in the tube *b*, at top, and from this tube the steam main *c* passes down to the floor of the basement story. From this main, a series of steam-pipes, as *d d*, extend over the surface of the floor, and from them heat is intended to be diffused for the purpose of warming the drying-house.

Along the middle of the building a strong beam of timber *e e*, extends, and is supported by cast-iron pillars; from this beam, to bearings on the side walls, a series of rails are carried in a cross direction, over which rails the wet cloth is to be hung in folds, and the steam or evaporation emitted in drying is allowed to escape through apertures or ventilators in the roof.

The mode in which the cloth is delivered on to the rails, on either side of the beam, will be best understood by reference to the delivering carriage, which is shown, with its rollers partly in section.

The wet cloth is first to be coiled upon a roller, and then placed in the carriage, as at *f*, with its pivots bearing upon inclined planes. The carriage is to be placed at the commencement of the rails, running upon the middle beam, and also upon the side-bearings or railways extending along the side walls of the building, parallel to and upon a level with the same beam. It is made to travel by means of an endless band passing over two riggers, *g* and *h*, in *fig.* 363, and over pulleys and a band-wheel attached to the carriage, as will be explained. The rigger *g*, which moves this endless band, is actuated by bevel gear, seen at *i*, which is put in motion by a pinion at the end of a revolving shaft leading from a steam engine.

In the same *fig.*, *k k* is the endless band passing over a pulley under the band-wheel, and over the pulley *n*, by which it will be perceived that the traversing of the band, as described, would cause these pulleys and wheels to revolve. On the axle of the band-wheel *m*, there is a drum against which the roll of wet cloth *f* presses, and as this drum revolves, the roll of wet cloth is, by its friction, made to turn in a contrary direction, and to deliver off the cloth on to the periphery of the drum, whence it passes over a roller and descends to the rails. Upon the end of the axle of the

n, there is a pinion which takes into the teeth of the large wheel, and upon
ιis large wheel there is a pinion that actuates the intermediate wheel, which
r toothed wheel. This last-mentioned toothed wheel takes into cogs upon
ϝay, and hence, as the train of wheels moves round, the carriage to which
re attached is slowly impelled forward.

ι the wheels begin to move, and the carriage to advance, the wet cloth
coil, and to pass down over the first roller; a small roller attached to the
ι passes over the rails in succession, holds the cloth against each rail for a
f time, and prevents it from slipping, by which means the cloth descends
ιops between the rails, and is thereby made to hang in a series of folds or
ϝn in the figure.

perceived that as the pivots of the cloth roller *f* bear upon inclined planes,
ll continually slide down as the cloth diminishes in bulk, keeping in con-
 drum, and delivering the cloth from the roller on to the several rails, as

stop the carriage in any part of its course, or to adjust any of the folds of
man is usually placed upon the platform travelling with the carriage, over
ι perfect command. This apparatus may be also employed for taking the
ʼied off the rails; in which case the carriage must be made to travel back-
y first guiding the end of the cloth on to the roller *f*, and then putting the
ɛtrograde motion, the cloth will be progressively coiled upon the roller *f*, in
 to that by which it was uncoiled.

ΓY (*Streckbarkeiʼ*, Germ.) is the property of being drawn out in length
ιing, possessed in a pre-eminent degree by gold and silver, as also by many
 by glass in the liquid state, and by many semifluid resinous and gummy
The spider and the silk-worm exhibit the finest natural exercise of ductility
ιliar viscid secretions from which they spin their threads. When a body
ʼ extended in all directions under the hammer, it is said to be malleable, and
ɛts under the rolling press, it is said to be laminable.

Table of the ductility and malleability of Metals.

ιle and ιhabetical	Brittle metals in alphabetical order.	Metals in the order of their wire-drawing ductility.	Metals in the order of their laminable ductility.
n.	Antimony.	Gold.	Gold.
	Arsenic.	Silver.	Silver.
	Bismuth.	Platinum.	Copper.
	Cerium. ?	Iron.	Tin.
	Chromium.	Copper.	Platinum.
	Cobalt.	Zinc.	Lead.
ιum.	Columbium.	Tin.	Zinc.
.	Iridium.	Lead.	Iron.
	Manganese.	Nickel.	Nickel.
	Molybdenum.	Palladium. ?	Palladium. ?
m.	Osmium.	Cadmium. ?	Cadmium. ?
ι.	Rhodium.		
m.	Tellurium.		ϳ
	Titanium.		
	Tungsten.		
	Uranium.		

ars to be, therefore, a real difference between ductility and malleability;
 which draw into the finest wire are not those which afford the thinnest
he hammer or in the rolling press. Of this fact iron affords a good illus-
ing the metals permanent in the air, 17 are ductile and 16 are brittle. But
ile cannot be wire-drawn or laminated to any considerable extent without
d from time to time during the progress of the extension, or rather the
particles alongside of each other, so as to loosen their lateral cohesion.

, in calico-printing, is the application of a bath of cowdung, diffused
ʻater, to cotton goods in a particular stage of the manufacture. Dunging
are commonly alternated, and are two of the most important steps in the
operation of dunging has for its objects :—

nine the entire combination of the aluminous sub-salts with the stuffs, by

separating almost all the acetic acid which was not volatilised in the stove-drying of the mordant.

2. To dissolve and carry off from the cloth a portion of the thickening matters.

3. To separate from the cloth the part of the mordant that is uncombined, and merely mixed mechanically with the gum or starch.

4. To prevent, by the peculiar action of the dung, the uncombined mordant, as well as the acetic acid with which the bath is apt to get loaded, from affecting the blank parts of the cloth, or being injurious to the mordant.

The aluminous base or mordant on the cloth, more or less neutralized by the dunging, is next subjected to the dash-wheel or fulling mill, where by the stream of water the remainder of the thickening and other impurities are washed away.

No very exact analysis has been made of cowdung. Morin's, which is the most recent and elaborate, is as follows:—

Water - - - - - - - -	70·00
Vegetable fibre - - - - · - -	24·06
Green resin and fat acids - - : - -	1·52
Undecomposed biliary matter - -	0·60
Peculiar extractive matter (*bububine*) - -	1·60
Albumen - - - - - - -	0·40
Biliary resin - - - · - - -	1·80

According to M. Kœchlin's practical knowledge on the great scale, it consists of a moist fibrous vegetable substance, which is animalized, and forms about one tenth of its weight; 2. of albumen; 3. of animal mucus; 4. of a substance similar to bile; 5. of muriate of soda, muriate and acetate of ammonia, phosphate of lime and other salts; 6. of benzoin or musk.

Probably the hot water in which the calico-printer diffuses the dung exerts a powerful solvent action, and in proportion as the uncombined mordant floats in the bath it is precipitated by the albumen, the animal mucus, and the ammoniacal salts; but there is reason to think that the fibrous matter in part animalized or covered with animal matter, plays here the principal part; for the great affinity of this substance for the aluminous salts is well known.

All practical men are aware that the affinity of cotton for alumina is increased by its combination with oil or animal substances, to such a degree as to take it from the dung bath; which would not be possible without this combination. It would therefore appear that the principal function of dunging is to hinder the uncombined mordant, diffused in the dung bath, from attaching itself to the unmordanted portion of the cloth, as already observed; for if we merely wished to abstract the thickening stuffs, or to complete by the removal of acetic acid the combination of the aluminous base with the goods, dung would not be required, for hot water would suffice. In fact, we may observe, that in such cases the first pieces passed through the boiler are fit for dyeing; but when a certain number have been passed through, the mordant now dissolved in the water is attracted to the white portions of the cloth, while the·free acid impoverishes the mordanted parts, so that they cannot afford good dyes, and the blank spaces are tarnished.

The cowdung may be in some measure replaced by bran, but not with perfect success. The former both answers the purpose better and is cheaper. The bran is only preferred for the most delicate yellows, for cochineal pinks and lilachs, to which the dung may sometimes impart a greenish cast. It is to be presumed that the action of the bran in this process has much analogy with that of the dung, and that the ligneous fibre is the most active constituent; with which the gluten and mucilage co-operate, no doubt, in seizing the aluminous salts.

It seems to be ascertained that the mordant applied to the cloth does not combine entirely with it during the drying; that this combination is more or less perfect according to the strength of the mordants, and the circumstances of the drying; that the operation of dunging, or passing through hot water, completes the combination of the cloth with the aluminous base now insoluble in water; that this base may still contain a very minute quantity of acetic acid or sulphate of alumina; that a long ebullition in water impoverishes the mordant but a little; and that even then the liquid does not contain any perceptible quantity of acetate or subsulphate of alumina.

The manner of immersing the goods, or passing them through the dung bath, is an important circumstance. They should be properly extended and free from folds, which is secured by a series of cylinders.

The cistern is from 10 to 12 feet long, 4½ feet wide, and 6 or 8 feet deep. The piece passes alternately over the upper rollers and under rollers near the bottom. There are two main squeezing rollers at one end, which draw the cloth through between them. Whenever the goods come out of the bath they are put into the dash-wheel—

nmersion should take place as fast as possible, for the moment the hot water pene-
the mordanted cloth, the acetic acid quits it; and, therefore, if the immersion was
slowly or one ply after another, the acid as well as the uncombined mordant become
rould spread their influence, and would have time to dissolve the aluminous sub-
iow combined with the cloth; whence inequalities and impoverishment of the colors
ensue.
ı difficult to determine the number of pieces which may be passed through a given
ty of dung and water. This depends upon the state of the mordants, whether
re strong or acid, and on the quantity of the surface covered with the figures.
umber varies usually from 20 to 60 pieces, for from 240 to 300 gallons of water
gallons of dung. The time of the immersion varies with the concentration of the
nts, and the nature of their thickening. The temperature must be regulated by
me circumstances; for starch or flour paste a much warmer bath is needed than
m. The heat varies usually from 130° to 212° F. When the printing is heavy
ıe thickening is starch or flour, the goods are usually twice dunged, with two wash-
ıetween the two dungs. A strong acid mordant is more difficult to dung and to
than a neutral mordant, especially when it is to receive the madder dye. Some-
a little chalk is added to the bath, when the goods have been padded in an acid
nt. Too much dung is injurious to weak mordants, as well as to pinks. It has
een remarked that a mordant when neutralized does not produce as brilliant tints,
ally yellows. The latter are obtained of a finer shade when, instead of dunging,
re exposed for an hour in a stream of water, provided its temperature is not too
In winter they are passed through a slightly chalky water, then washed at the
, and dyed in quercitron or weld.
ery able and learned memoir upon this subject, by M. Penot, Professor of Chem-
appeared in the Bulletin of the Society of Mulhausen, in October, 1834, with an
ous commentary upon it, under the title of a Report by M. Camille Kœchlin, in
ı, 1835.
ierience has proved that dunging is one of the most important steps in the process
ico printing, and that if it be not well performed the dyeing is good for nothing.
ı we can assign its peculiar function to the dung in this case, we must know its
sition. Fresh cow's dung is commonly neutral when tested by litmus paper; but
imes it is slightly alkaline, owing, probably, to some peculiarity in the food of the
l.
ı total constituents of 100 parts of cow dung are as follows: Water, 69·58; bitter
ı, 0·74; sweet substance, 0·93; chlorophylle, 0·28; albumine, 0·63; muriate of
0·08; sulphate of potash, 0·05; sulphate of lime, 0·25; carbonate of lime, 0·24;
hate of lime, 0·46; carbonate of iron, 0·09; woody fibre, 26·39; silica, 0·14;
ı·14.
lunging calicoes the excess of uncombined mordant is in part attracted by the
e matters of the cow's dung, and forms an insoluble precipitate, which has no
y for the cloth, especially in presence of the insoluble part of the dung, which
ly attracts alumina. The most important part which that insoluble matter plays,
seize the excess of the mordants, in proportion as they are dissolved by the water
bath, and thus to render their reaction upon the cloth impossible. It is only in
eposite, therefore, that the matters carried off from the cloth by the dung are to
ınd.
Camille Kœchlin ascribes the action of cow dung chiefly to its albuminous con-
ıt, combining with the alumina and iron, of the acetates of these bases dissolved
ı hot water of the bath. The acids consequently set free, soon become evident by
st of litmus paper, after a few pieces are passed through, and require to be got rid
ıer by a fresh bath or by adding chalk to the old one. The dung thus serves also
the bases on the cloth, when used in moderation. It exercises likewise a disoxyda-
ower on the iron mordant, and restores it to a state more fit to combine with color-
ıtter.
EING, (*Teinture*, Fr.; *Färberei*, Germ.) is the art of impregnating wool, silk,
ı, linen, hair, and skins, with colors not removable by washing, or the ordinary
to which these fibrous bodies are exposed when worked up into articles of furniture
iment. I shall here consider the general principles of the art, referring for the
nlar dyes, and peculiar treatment of the stuffs to be dyed, to the different tinctorial
inces in their alphabetical places; such as cochineal, indigo, madder, &c.
eing is altogether a chemical process, and requires for its due explanation and
ice an acquaintance with the properties of the elementary bodies, and the laws
h regulate their combinations. It is true that many operations of this, as of other
ıical arts, have been practised from the most ancient times, long before any just
ı were entertained of the nature of the changes that took place. Mankind, equally
e rudest and most refined state, have always sought to gratify the love of distinction

by staining their dress, sometimes even their skin, with gaudy colors. Moses speaks of raiment dyed blue, and purple, and scarlet, and of sheep skins dyed red; circumstances which indicate no small degree of tinctorial skill. He enjoins purple stuffs for the works of the tabernacle and the vestments of the high priest.

In the article CALICO PRINTING, I have shown from Pliny that the ancient Egyptians cultivated that art with some degree of scientific precision, since they knew the use of mordants, or those substances which, though they may impart no color themselves, yet enable white robes (*candida vela*) to absorb coloring drugs (*colorem sorbendibus medicamentis*). Tyre, however, was the nation of antiquity which made dying its chief occupation and the staple of its commerce. There is little doubt that purple, the sacred symbol of royal and sacerdotal dignity, was a color discovered in that city, and that it contributed to its opulence and grandeur. Homer marks no less the value than the antiquity of this dye, by describing his heroes as arrayed in purple robes. Purple habits are mentioned among the presents made to Gideon by the Israelites from the spoils of the kings of Midian.

The juice employed for communicating this dye was obtained from two different kinds of shell-fish, described by Pliny under the names of *purpura* and *buccinum*; and was extracted from a small vessel, or sac, in their throats, to the amount of only one drop from each animal. A darker and inferior color was also procured by crushing the whole substance of the buccinum. A certain quantity of the juice collected from a vast number of shells being treated with sea-salt was allowed to ripen for three days; after which it was diluted with five times its bulk of water, kept at a moderate heat for six days more, occasionally skimmed to separate the animal membranes, and when thus clarified was applied directly as a dye to white wool, previously prepared for this purpose by the action of lime-water, or of a species of lichen called fucus. Two operations were requisite to communicate the finest Tyrian purple; the first consisted in plunging the wool into the juice of the purpura : the second, into that of the buccinum. Fifty drachms of wool required one hundred of the former liquor, and two hundred of the latter. Sometimes a preliminary tint was given with coccus, the kermes of the present day, and the cloth received merely a finish from the precious animal juice. The colors, though probably not nearly so brilliant as those producible by our cochineal, seem to have been very durable, for Plutarch says, in his *Life of Alexander*, (chap. 36,) that the Greeks found in the treasury of the King of Persia a large quantity of purple cloth, which was as beautiful as at first, though it was 190 years old.[*]

The difficulty of collecting the purple juice, and the tedious complication of the dyeing process, made the purple wool of Tyre so expensive at Rome, that in the time of Augustus a pound of it cost nearly 30*l.* of our money.[†] Notwithstanding this enormous price, such was the wealth accumulated in that capital, that many of the leading citizens decorated themselves in purple attire, till the emperors arrogated to themselves the privilege of wearing purple, and prohibited its use to every other person. This prohibition operated so much to discourage this curious art as eventually to occasion its extinction, first in the western and then in the eastern empire, where, however, it existed in certain imperial manufactures till the eleventh century.

Dyeing was little cultivated in ancient Greece; the people of Athens wore generally woollen dresses of the natural color. But the Romans must have bestowed some pains upon this art. In the games of the circus parties were distinguished by colors. Four of these are described by Pliny, the green, the orange, the gray, and the white. The following ingredients were used by their dyers. A crude native alum mixed with copperas, copperas itself, blue vitriol, alkanet, lichen rocellus, or archil, broom, madder, woad, nut-galls, the seed of pomegranate, and of an Egyptian acacia.

Gage, Cole, Plumier, Reaumur, and Duhamel have severally made researches concerning the coloring juices of shell-fish caught on various shores of the ocean, and have succeeded in forming a purple dye, but they found it much inferior to that furnished by other means. The juice of the buccinum is at first white; it becomes by exposure to air of a yellowish green bordering on blue; it afterwards reddens, and finally changes to a deep purple of considerable vivacity. These circumstances coincide with the minute description of the manner of catching the purple-dye shell-fish which we possess in the work of an eye-witness, Eudocia Macrembolitissa, daughter of the Emperor Constantine VIII, who lived in the eleventh century.

The moderns have obtained from the New World several dye-drugs unknown to the ancients; such as cochineal, quercitron, Brazil wood, logwood, annatto; and they have

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[*] "Among other things, there was purple of Hermione (?) to the amount of five thousand talents." (Plutarch's Lives, translated by Langhorne, Wranghaus's edition, vol. v. p. 240.) Horace celebrates the Laconian dye in the following lines :—

> Nec Laconicas mihi
> Trahunt honestæ purpuras clientæ.
> (Carm. lib. ii., Ode 18.)

[†] Pliny says that a pound of the double-dipped Tyrian purple was sold in Rome for a hundred crowns.

discovered the art of using indigo as a dye, which the Romans knew only as a pigment. But the vast superiority of our dyes over those of former times must be ascribed principally to the employment of pure alum and solution of tin as mordants, either alone or mixed with other bases; substances which give to our common dye-stuffs remarkable depth, durability, and lustre. Another improvement in dyeing of more recent date is the application to textile substances of metallic compounds, such as Prussian blue, chrome yellow, manganese brown, &c.

Indigo, the innoxious and beautiful product of an interesting tribe of tropical plants, which is adapted to form the most useful and substantial of all dyes, was actually denounced as a dangerous drug, and forbidden to be used, by our parliament in the reign of Queen Elizabeth. An act was passed authorizing searchers to burn both it and log-wood in every dye-house where they could be found. This act remained in full force till the time of Charles II.; that is, for a great part of a century. A foreigner might have supposed that the legislators of England entertained such an affection for their native woad, with which their naked sires used to dye their skins in the old times, that they would allow no outlandish drug to come in competition with it. A most instructive book might be written illustrative of the evils inflicted upon arts, manufactures, and commerce, in consequence of the ignorance of the legislature.*

Colors are not, properly speaking, material; they are impressions which we receive from the rays of light reflected, in a decomposed state, by the surfaces of bodies. It is well known that a white sunbeam consists of an indeterminate number of differently colored rays, which being separated by the refractive force of a glass prism, form the solar spectrum, an image distinguishable into seven sorts of rays; the red, orange, yellow, green, blue, indigo, and violet. Hence, when an opaque body appears colored, for example, red, we say that it reflects the red rays only, or in greatest abundance, mixed with more or less of the white beam, which has escaped decomposition. According to this manner of viewing the coloring principle, the art of dyeing consists in fixing upon stuffs, by means of corpuscular attraction, substances which act upon light in a different manner from the surfaces of the stuffs themselves. The dyer ought, therefore, to be familiar with two principles of optics; the first relative to the mixture of colors, and the second to their simultaneous contrast.

Whenever the different colored rays, which have been separated by the prism, are totally reunited, they reproduce white light. It is evident, that in this composition of light, if some rays were left out, or if the colored rays be not in a certain proportion, we should not have white light, but light of a certain color. For example; if we separate the red rays from the light decomposed by a prism, the remaining colored rays will form by their combination a peculiar bluish green. If we separate in like manner the orange rays, the remaining colored rays will form by their combination a blue color. If we separate from the decomposed prismatic light the rays of greenish yellow, the remaining colored rays will form a violet. And if we separate the rays of yellow bordering on orange, the remaining colored rays will form by their union an indigo color.

Thus we see that every colored light has such a relation with another colored light that, by uniting the first with the second, we reproduce white light; a relation which we express by saying that the one is the complement of the other. In this sense, red is the complementary color of bluish green; orange, of blue; greenish yellow, of violet; and orange yellow, of indigo. If we mix the yellow ray with the red, we produce orange; the blue ray with the yellow, we produce green; and the blue with the red, we produce violet or indigo, according as there is more or less red relatively to the blue. But these tints are distinguishable from the orange, green, indigo, and violet of the solar spectrum, because when viewed through the prism they are reduced to their elementary compound colors.

If the dyer tries to realize the preceding results by the mixture of dyes, he will succeed only with a certain number of them. Thus, with red and yellow he can make orange; with blue and yellow, green; with blue and red, indigo or violet. These facts, the results of practice, have led him to conclude that there are only three primitive colors; the red, yellow, and blue. If he attempts to make a white, by applying red, yellow, and blue dyes in certain quantities to a white stuff, in imitation of the philosopher's experiment on the synthesis of the sunbeam, far from succeeding, he will deviate still further from his purpose, since the stuff will by these dyes become so dark colored as to appear black.

The fact must not, however, lead us to suppose that in every case where red, yellow, and blue are applied to white cloth, black is produced. In reality, when a little ultramarine, cobalt blue, Prussian blue, or indigo, is applied to goods with the view of giving them the best possible white, if only a certain proportion be used, the goods will appear whiter after this addition than before it. What happens in this case? The violet blue

* Author, in Penny Cyclopedia.

forms, with the brown yellow of the goods, a mixture tending to white, or less colored than the yellow of the goods and the blue together were. For the same reason, a mixture of Prussian blue and cochineal pink has been of late years used in the whitening or the azuring of silks, in preference to a pure blue; for on examining closely the color of the silk to be neutralized, it was found by the relations of the complementary colors, that the violet was more suitable than the indigo blue formerly used. The dyer should know, that when he applies several different coloring matters to stuffs, as yellow and blue, for example, if they appear green, it is because the eye cannot distinguish the points which reflect the yellow from those which reflect the blue; and that, consequently, it is only where the distinction is not possible, that a mixture or combination appears. When we examine certain gray substances, such as hairs, feathers, &c., with the microscope, we see that the gray color results from black points disseminated over a colorless or slightly colored surface. In reference to compound colors, this instrument might be used with advantage by the dyer.

The dyer should be acquainted also with the law of the simultaneous contrast of colors. When the eye views two colors close alongside of each other, it sees them differing most in their optical composition, and in the height of their tone, when the two are not equally pale or full-bodied. They appear most different as to their optical composition, when the complementary of the one of them is added to the color of the other. Thus, put a green zone alongside of an orange zone; the red color complementary of green, being added to the orange, will make it appear redder; and in like manner the blue, complementary of orange, being added to the green, will make it appear more intensely blue. In order to appreciate these differences, let us take two green stripes and two orange stripes, placing one of the green stripes near one of the orange: then place the two others so that the green stripe may be at a distance from the other green stripe, but on the same side, and the orange at a distance from the other orange, also on the same side.

As to the contrast in the height of the tone, we may satisfy ourselves by taking the tones No. 1, No. 2, No. 15, and No. 16, from a graduated pallet of reds: for example, by placing No. 2 and No. 15 close alongside, putting No. 1 at a distance from No. 2 on the same side, and No. 16 at a distance from No. 15 on the same side,—we shall see (if the pallet is sufficiently lowered in tone) No. 2 equal to No. 1, and No. 15 equal to No. 16; whence it follows that No. 2, by the vicinity of No. 15, will appear to have lost some of its color; while No. 15 will appear to have acquired color. When black or gray figures are printed upon colored grounds, these figures are of the color complementary of the ground. Consequently, in order to judge of their color, we must cut out spaces in a piece of gray or white paper, so as to allow the eye to see nothing but the figures; and if we wish to compare figures of the same color, applied upon grounds of different colors, we can judge rightly of the figures only by insulating them from the grounds.

The relations of dyeing with the principles of chemistry, constitute the theory of the art, properly speaking; this theory has for its basis, the knowledge—1. of the species of bodies which dyeing processes bring into contact; 2. of the circumstances in which these species act; 3. of the phenomena which appear during their action; and 4. of the properties of the colored combinations which are produced. These generalities may be specified under the ten following heads :—

1. The preparation of the stuffs to be dyed, whether fibres, yarn, or cloth; under the heads of ligneous matter, cotton, hemp, flax; and of the animal matters, silk and wool.

2. The mutual action of these stuffs, and simple bodies.

3. The mutual action of these stuffs, and acids.

4. The mutual action of these stuffs, and salifiable bases, as alumina, &c.

5. The mutual action of these stuffs, and salts.

6. The mutual action of these stuffs, and neutral compounds not saline.

7. The mutual action of these stuffs, and of one or more definite compounds.

8. Of dyed stuffs considered in reference to the fastness of their color, under the influence of heat, light, water, oxygen, air, boilings with soap, and reagents.

9. Of dyeing, considered in its connexions with chemistry.

10. Of dyeing, considered in its relations with caloric, mechanics, hydraulics, and optics.

1. The preparation of stuffs.

The operations to which stuffs are subjected before dyeing, are intended—1. to separate from them any foreign matters; 2. to render them more apt to unite with the coloring tinctures which the dyer proposes to fix upon them, in order to give them a more agreeable, or more brilliant aspect, or to lessen their tendency to assume a soiled appearance by use, which white surfaces so readily do. The foreign matters are either naturally inherent in the stuffs, or added to them in the spinning, weaving, or other

manipulation of manufacture. The ligneous fibres must be freed from the colored azotized varnish on their surface, from a yellow coloring matter in their substance, from some lime and iron, from chlorophylle or leaf-green, and from pectic acid; all natural combinations. Some of these principles require to be oxygenized before alkaline leys can cleanse them, as I have stated in the article BLEACHING, which may be consulted in reference to this subject. See also SILK and WOOL. A weak bath of soda has the property of preparing wool for taking on a uniform dye, but it must be well rinsed and aired before being put into the dye-vat.

2. Mutual action of stuffs and simple bodies.

Stuffs chemically considered being composed of three or four elements, already in a state of reciprocal saturation, have but a feeble attraction for simple substances. We know in fact, that the latter combine only with each other, or with binary compounds, and that in the greater number of cases where they exert an action upon more complete compounds, it is by disturbing the arrangement of their elements, and not by a resulting affinity with the whole together.

3, 4. Although stuffs may in a general point of view be considered as neutral in relation to coloring reagents, yet experience shows that they are more disposed to combine with acid than with alkaline compounds; and that consequently their nature seems to be more alkaline than acid. By steeping dry wool or other stuff in a clean state in an alkaline or acid solution of known strength, and by testing the liquor after the stuff is taken out, we shall ascertain whether there be any real affinity between them, by the solution being rendered more dilute in consequence of the abstraction of alkaline or acid particles from it. Wool and silk thus immersed, abstract a portion of both sulphuric and muriatic acids; but cotton and flax imbibe the water, with the rejection of a portion of the acid. The acid may be again taken from the stuffs by washing them with a sufficient quantity of water.

5. The affinity between saline bodies and stuffs may be ascertained in the same way as that of acids, by plunging the dry stuffs into solutions of the salts, and determining the density of the solution before the immersion, and after withdrawing the stuffs. Wool abstracts alum from its solution, but it gives it all out again to boiling water. The sulphates of protoxyde of iron, of copper, and zinc, resemble alum in this respect. When silk is steeped for some time in a solution of protosulphate of iron, it abstracts the oxyde, gets thereby dyed, and leaves the solution acidulous. Wool put in contact with cream of tartar decomposes a portion of it; it absorbs the acid into its pores, and leaves a neutral salt in the liquor. The study of the action of salts upon stuffs is at the present day the foundation of the theory of dyeing; and some of them are employed immediately as dye-drugs.

6. Mutual action of stuffs, and neutral compounds not saline.

Several sulphurets, such as those of arsenic, lead, copper, antimony, tin, are susceptible of being applied to stuffs, and of dyeing them in a more or less fast manner. Indigo, hematine, breziline, carmine, and the peculiar coloring principles of many dyes belong to this division.

7. Mutual action of goods with one or more definite compounds, and dye-stuffs.

I shall consider here in a theoretical point of view, the most general results which a certain number of organic coloring matters present, when applied upon stuffs by the dyer.

Indigo. This dye-drug, when tolerably good, contains half its weight of indigotine. The cold vat is prepared commonly with water, copperas, indigo, lime, or sometimes carbonate of soda, and is used almost exclusively for cotton and linen; immersion in acidulated water is occasionally had recourse to for removing a little oxyde of iron which attaches itself to the cloth dyed in this vat.

The indigo vat for wool and silk is mounted exclusively with indigo, good potashes of commerce, madder, and bran. In this vat, the immediate principles with base of carbon and hydrogen, such as the extracts of madder and bran, perform the disoxydizing function of the copperas in the cold vat. The pastel vats require most skill and experience, in consequence of their complexity. The greatest difficulty occurs in keeping them in a good condition, because they vary progressively as the dyeing goes on, by the abstraction of the indigotine, and the modification of the fermentable matter employed to disoxygenate the indigo. The alkaline matter also changes by the action of the air. By the successive additions of indigo, alkali, &c., this vat becomes very difficult to manage with profit and success. The great affair of the dyer is the proper addition of lime; too much or too little being equally injurious.

Sulphate of indigo or Saxon blue is used also to dye silk and wool. If the wools be ill sorted, it will show their differences by the inequalities of the dye. Wool dyed in this bath put into water saturated with sulphureted hydrogen, becomes soon colorless, owing to the disoxygenation of the indigo. The woollen cloth, when exposed to the air for some time resumes its blue color, but not so intensely as before.

The properties of hematine explain the mode of using logwood. When stuffs are dyed in the infusion or decoction of this wood, under the influence of a base which acts upon the hematine in the manner of an alkali, a blue dye, bordering upon violet, is obtained. Such is the process for dyeing cotton and wool a logwood blue by means of verdigris, crystallized acetate of copper, and acetate of alumina.

When we dye a stuff yellow, red, or orange, we have always bright tints; with these, we may have a very dark shade, but somewhat violet; the proper black can be obtained only by using the three colors, blue, red, and yellow, in proper proportions. Hence we can explain how the tints of yellow, red, orange, blue, green, and violet, may be browned, by applying to them one or two colors which along with themselves would produce black; and also we may explain the nature of that variety of blacks and grays which seems to be indefinite. Nutgalls and sulphate of iron, so frequently employed for the black dye, give only a violet or bluish gray. The pyrolignite of iron, which contains a brown empyreumatic matter, gives to stuffs a brown tint, bordering upon greenish yellow in the pale hues, and to chestnut brown in the dark ones. By galling cotton and silk, and giving them a bath of pyrolignite of iron, we may, after some alterations, dye them black. Galls, logwood, and a salt of iron, produce merely a very deep violet blue; but by boiling and exposure to air, the hematate of iron is changed, becoming red-brown, and favors the production of black. Galls and salts of copper dye stuffs an olive drab, logwood and salts of copper, a violet blue; hence their combination should produce a black. In using sumach as a substitute for galls, we should take into account the proportion of yellow matter it contains. When the best possible black is wanted upon wool, we must give the stuff a foundation of indigo, then pass it into a bath of logwood, sumach, and proto-sulphate of iron. The sumach may be replaced by one third of its weight of nutgalls.

8. Of dyed stuffs considered in reference to the fastness of their colors, when exposed to water, light, heat, air, oxygen, boiling, and reagents.

Pure water without air has no action upon any properly dyed stuff.

Heat favors the action of certain oxygenized bodies upon the carbonaceous and hydrogenous constituents of the stuff; as is seen with regard to chromic acid, and peroxyde of manganese upon cotton goods. It promotes the solvent action of water, and it even affects some colors. Thus Prussian blue applied to silk, is reduced to peroxyde of iron by long boiling.

Light without contact of air affects very few dyes.

Oxygen, especially in the nascent state, is very powerful upon dyes. See BLEACHING.

The atmosphere in a somewhat moist state affects many dyes, at an elevated temperature. Silk dyed pink, with safflower, when heated to 400° F., becomes of a dirty white hue in the course of an hour. The violet of logwood upon alumed wool becomes of a dull brown at the same temperature in the same time. But both stand a heat of 300° F. Brazil red dye, turmeric, and weld yellow dyes, display the same phenomena. These facts show the great fixity of colors commonly deemed tender. The stuffs become affected to a certain degree, under the same circumstances as the dyes. The alterability even of indigo in the air is shown in the wearing of pale blue clothes; in the dark blue cloth there is such a body of color, that it resists proportionally longer; but the seams of coats exhibit the effect very distinctly. In silk window curtains, which have been long exposed to the air and light, the stuff is found to be decomposed, as well as the color.

Boiling was formerly prescribed in France as a test of fast dyes. It consisted in putting a sample of the dyed goods in boiling water, holding in solution a determinate quantity of alum, tartar, soap, and vinegar, &c. Dufay improved that barbarous test. He considered that fast-dyed cloth could be recognised by resisting an exposure of twelve hours to the sunshine of summer, and to the midnight dews; or of sixteen days in winter.

In trying the stability of dyes, we may offer the following rules:—

That every stuff should be exposed to the light and air; if it be intended to be worn abroad, it should be exposed also to the wind and rain; that carpets, moreover, should be subjected to friction and pulling, to prove their tenacity; and that cloths to be washed should be exposed to the action of hot water and soap.

In examining a piece of dyed cotton goods, we may proceed as follows:—

Suppose its color to be orange-brown. We find first that it imparts no color to boiling water; that protochloride of tin takes out its color; that plunged into a solution of ferroprussiate of potash it becomes blue; and that a piece of it being burned, leaves a residuum of peroxyde of iron; we may thence conclude that the dyeing matter is peroxyde of iron.

Suppose we have a blue stuff which may have been dyed either with indigo or with Prussian blue, and we wish to know what it will become in use. We inquire first into the nature of the blue. Hot water slightly alkaline will be colored blue by it, if

It has been dyed with sulphate of indigo; it will not be colored if it was dyed in the indigo vat, but it will become yellow by nitric acid. Boiling water, without becoming colored itself, will destroy the Prussian blue dye; an alkaline water will convert its color into an iron rust tint; nitric acid, which makes the indigo dye yellow, makes that of Prussian blue green. The liquor resulting from boiling alkaline water on the Prussian blue cloth, will convert sulphate of iron into Prussian blue.

9. Division. Of dyeing viewed in its relation to chemistry.

The phenomena of dyeing have been ascribed to very different causes; by some they were supposed to depend upon mechanical causes, and by others upon the forces from which chemical effects flow. Hellot, in conformity with the first mode of explanation, thought that the art of dyeing consisted essentially in opening the pores in order to admit coloring matters into them, and to fix them there by cooling, or by means of a mordant imagined to act like a cement.

Dufay in 1737, Bergmann in 1776, Macquer in 1778, and Berthollet in 1790, had recourse to chemical affinities, to explain the fixation of the coloring principles upon stuffs, either without an intermedium, like indigo, walnut peels, annotto; or by the intervention of an acid, a salifiable base, or a salt, which were called mordants. When bodies present phenomena which we refer to an attraction uniting particles of the same nature, whether simple or compound, to form an aggregate, or to an affinity which unites the particles of different natures to form them into a chemical compound, these bodies are in apparent contact. This happens precisely in all the cases of the mutual action of bodies in an operation of dyeing; if their particles were not in apparent contact, there would be absolutely no change in their respective condition. When we see stuffs and metallic oxydes in apparent contact, form a mutual union of greater or less force, we cannot therefore help referring it to affinity. We do not know how many dyes may be fixed upon the same piece of cloth; but in the operations of the dye-house sufficiently complex compounds are formed, since they are always stuffs, composed of three or four elements, which are combined with at least binary acid or basic compounds; with simple salts compounded themselves of two immediate principles at least binary; with double salts composed of two simple salts; and finally with organic dye-stuffs containing three or four elements. We may add that different species belonging to one of these classes, and different species belonging to different classes, may unite simultaneously with one stuff. The union of stuffs with coloring matters appears, in general, not to take place in definite proportions; though there are probably some exceptions.

We may conclude this head by remarking, that, besides the stuff and the coloring matter, it is not necessary, in dyeing, to distinguish a third body, under the name of *mordant ;* for the idea of mordant does not rest upon any definite fact; the body to which this name has been given being essentially only one of the immediate principles of the colored combination which we wish to fix upon the stuff.

10. Division. Of dyeing in its relation with caloric, mechanics, hydraulics, pneumatics, and optics.

Dyeing baths, or coppers, are heated directly by a furnace, or by means of steam conducted in a pipe from a boiler at a certain distance from the bath. In the first case, the vessels are almost always made of copper; only, in special cases, for the scarlet and some delicate silk dyes, of tin; in the second case, they are of copper, iron, or wood. A direct fire is more economical than heating steam pipes, where there is only one or two baths to heat, or where the labors are often suspended. Madder and indigo vats, when heated by steam, have it either admitted directly into the liquor, or made to circulate through pipes plunged into it, or between the copper and an exterior iron or wood case. See the end of this article.

Everything else being equal, dyeing with heat presents fewer difficulties towards obtaining an evenly color, than dyeing in the cold; the reason of which may be found in the following facts :—The air adhering to the surface of stuffs, and that interposed between the fibres of their constituent yarns, is more easily extricated in a hot bath than a cold one, and thus allows the dye liquor to penetrate more easily into their interior : in the second place, the currents which take place in a hot bath, and which tend incessantly to render its contents uniform, by renewing continually the strata of liquid in contact with the stuff, contribute mainly to render the dyeing evenly. In cold dyeing, it is necessary to stir up the bath from time to time : and when goods are first put in, they must be carefully dipped, then taken out, pressed, and wrung, several times in succession till they be uniformly moistened.

The mechanical relations are to be found in the apparatus employed for wincing, stiring, and pressing the goods, as we have described under CALICO PRINTING and BANDANA. The hydraulic relations refer to the wash-wheels and other similar apparatus, of which an account is given under the same articles. The optical relations

have been already considered. In the sequel of this article an automatic dyeing vat will be described.

The extracts of solutions of native dye-stuffs may be divided into two classes, in reference to their habitudes with the oxygen of the atmosphere; such as continue essentially unaltered in the air, and such as suffer oxydation, and thereby precipitate a determinate coloring matter. The dyes contained in the watery infusions of the different vegetable and animal substances which do not belong to the second class, are feebly attached to their solvents, and quit them readily for any other bodies that possess an attraction for them. On this principle, a decoction of cochineal, logwood, brazil wood, or a solution of sulphate of indigo, by digestion with powdered bone black, lose their color, in consequence of the coloring particles combining by a kind of capillary attraction with the porous carbon, without undergoing any change. The same thing happens when well-scoured wool is steeped in such colored liquids; and the color which the wool assumes by its attraction for the dye, is, with regard to most of the above colored solutions, but feeble and fugitive, since the dye may be again abstracted by copious washing with simple water, whose attractive force therefore overcomes that of the wool. The aid of a high temperature, indeed, is requisite for the abstraction of the color from the wool and the bone-black, probably by enlarging the size of the pores, and increasing the solvent power of the water.

Those dye-baths, on the contrary, whose coloring matter is of the nature of extractive or apothème, form a faster combination with stuffs. Thus the yellow, fawn, and brown dyes, which contain tannin and extractive, become oxygenated by contact of air, and insoluble in water; by which means they can impart a durable dye. When wool is impregnated with decoctions of that kind, its pores get charged by capillarity, and when the liquid becomes oxygenated, they remain filled with a color now become insoluble in water. A similar change to insolubility ensues when the yellow liquor of the indigo vat gets oxydised in the pores of cotton and wool, into which it had been introduced in a fluid state. The same change occurs when protosulphate of iron is converted into persulphate, with the deposition of an insoluble peroxyde in the substance of the stuff. The change here effected by oxydation can, in other circumstances, be produced by acids which have the power of precipitating the dye-stuff in an insoluble state, as happens with decoction of fustic.

Hence we perceive that the dyeing of fast colors rests upon the principle, that the colors dissolved in the vat, during their union with the stuff, should suffer such a change as to become insoluble in their former menstruum. The more this dye, as altered in its union with the stuff, can resist other menstrua or agents, the faster it will be. This is the essential difference between dyeing and painting; or applying a coat of pigment devoid of any true affinity for the surface.

If we mix a clear infusion of a dye with a small quantity of a solution of an earthy or metallic salt, both in water, the limpid liquids soon become turbid, and there gradually subsides sooner or later, according to the nature of the mixture, a colored precipitate, consisting of the altered dye united with a basic or subsalt. In this compound the coloring matter seems to act the part of an acid, which is saturated by a small quantity of the basis, or in its acid relationship is feeble, so that it can also combine with acids, being in reference to them a base. The decomposition of a salt, as alum, by dyes, is effected principally through the formation of an insoluble subsalt, with which the color combines, while a supersalt remains in the bath, and modifies, by its solvent reaction, the shade of the dyed stuff. Dyed stuffs may be considered as composed of the fibrous body intimately associated with the coloring matter, the oxyde, and acid, all three constituting a compound salt. Many persons have erroneously imagined, that dyed goods contained none of the acid employed in the dye bath; but they forget that even potash added to alum does not throw down the pure earthy basis, but a subsalt; and they should not ascribe to coloring matter a power of decomposition at all approaching to that of an alkali. Salts, containing strong acids, saturate a very large quantity of coloring matter, in proportion to their place in the scale of chemical equivalents. Mere bases, such as pure alumina, and pure oxyde of tin, have no power of precipitating coloring matter; when they seem to do so, they always contain some acid.

Such salts, therefore, as have a tendency to pass readily into the basic state, are peculiarly adapted to act as mordants in dyeing, and to form colored lakes. Magnesia affords as fine a white powder as alumina, and answers equally well to dilute lakes, but its soluble salts cannot be employed to form lakes, because they do not pass into the basic state. This illustration is calculated to throw much light upon dyeing processes in general.

The color of the lake depends very much upon the nature of the acid, and the basis of the precipitating salt. If it be white, like alumina and oxyde of tin, the lake will have, more or less, the color of the dye, but brightened by the reflection of white

ight from the basis; while the difference of the acid occasions a difference in the hue. The colored bases impart more or less of their color to the lakes, not merely in virtue of their own tints, but of their chemical action upon the dye.

Upon these principles a crimson precipitate is obtained from infusions of cochineal by alum and salt of tin, which becomes scarlet by the addition of tartar; by acetate of lead, a violet blue precipitate is obtained, which is durable in the air; by muriate of lime, a pink brown precipitate falls, which soon becomes black, and at last, dirty green; by the solution of a ferruginous salt, the precipitates are dark violet and black; and, in like manner, all other salts with earthy or metallic bases, afford diversities of shade with cochineal. If this dye stuff be dissolved in weak water of ammonia, and be precipitated with acetate of lead, a green lake is obtained, which, after some time, will become green on the surface by contact of air, but violet and blue beneath. Hence it appears, that the shade of color of a lake depends upon the degree of oxydation or change of the color caused by the acid of the precipitating salt, upon the degree of oxylation or color of the oxyde which enters into union with the dye, and upon its quantity in reference to that of the coloring principle.

Such lakes are the difficultly soluble salts which constitute the dyeing materials of stuffs. Their particles, however, for the purposes of dyeing, must exist in a state of extremely fine division in the bath liquor, in order that they may penetrate along with it into the minute pores of textile fibres, and fill the cavities observed by means of the microscope in the filaments of wool, silk, cotton, and flax. I have examined these stuffs with an achromatic microscope, and find that when they are properly dyed with fast colors, the interior of their tubular texture is filled, or lined at least, with coloring matter. When the bath contains the coloring particles, so finely divided that they can pass through filtering paper, it is capable of dyeing; but if the infusion mixed with its mordant be flocculent and ready to subside, it is unfit for the purpose. In the latter case, the ingredients of the dye have already become aggregated into compounds too coherent and too gross for entering into combination with fibrous stuffs. Extractive matter and annin are particularly liable to a change of this kind, by the prolonged action of heat in the bath. Hence, also, an alkaline solution of a coloring matter affords no useful dye bath, when mixed with the solution of a salt having an earthy or metallic basis.

These circumstances, which are of frequent occurrence in the dye-house, render it necessary always to have the laky matter in a somewhat soluble condition, and to effect its precipitation within the pores of the stuffs, by previously impregnating them with the saline solutions by the aid of heat, which facilitates their introduction.

When a mordant is applied to any stuff, the portion of it remaining upon the surface of the fibres should be removed; since, by its combination with the coloring matter, it would be apt to form an external crust of mere pigment, which would block up the pores, obstruct the entrance of the dye into the interior, and also exhaust to no purpose the dyeing power of the bath. For this reason the stuffs, after the application of the mordant, are drained, squeezed, washed, and sometimes (particularly with cotton and linen, in calico printing) even hard dried in a hot stove.

The saline mordants, moreover, should not in general possess the crystallizing property in any considerable degree, as this opposes their affinity of composition for the cloth. On this account the deliquescent acetates of iron and alumina are more ready to aid the dyeing of cotton than copperas and alum.

Alum is the great mordant employed in wool dyeing. It is frequently dissolved in water, holding tartar equal to one fourth the weight of the alum in solution; by which addition its tendency to crystallize is diminished, and the resulting color is brightened. The alum and tartar combine with the stuff without suffering any change, and are decomposed only by the action of the coloring matters in the dye bath. The alum operates solely in virtue of its sulphuric acid and earthy basis; the sulphate of potash present in that salt being rather injurious. Hence, if a sulphate of alumina free from iron could be readily obtained, it would prove a preferable mordant to alum. It is also probable, for the reasons above assigned, that soda alum, a salt much less apt to crystallize than potash or ammonia alum, would suit the dyer very well. In order to counteract the tendency of common alum to crystallize, and to promote its tendency to pass into a basic salt, one eighth part of its weight of potash is added to its solution, or the equivalent in chalk or soda.

We shall conclude this account of the general principles of dyeing, with Mr. Delaval's observations on the nature of dyes, and a list of the different substances used in dyeing, in reference to the colors produced by them.

Sir Isaac Newton supposed colored matters to reflect the rays of light; some bodies reflecting the more, others the less, refrangible rays most copiously; and this he conceived to be the true, and the only reason of their colors. Mr. Delaval, however, proved, in the 2d vol. of the "Memoirs of the Philosophical and Literary Society of Manchester," that, "in transparent colored substances, the coloring substance does not reflect any

light; and that when, by intercepting the light which was transmitted, it is hindered from passing through substances, they do not vary from their former color to any other color, but become entirely black;" and he instances a considerable number of colored liquors, none of them endued with reflective powers, which, when seen by transmitted light, appeared severally in their true colors; but all of them, when seen by incident light, appeared black; which is also the case of black cherries, black currants, black berries, &c., the juices of which appeared red when spread on a white ground, or otherwise viewed by transmitted instead of incident light; and he concludes, that bleached linen, &c., "when dyed or painted with vegetable colors, do not differ in their manner of acting on the rays of light, from natural vegetable bodies; both yielding their colors by transmitting through the transparent colored matter the light which is reflected from the white ground:" it being apparent, from different experiments, "that no reflecting power resides in any of their components, except in their white matter only," and that "transparent colored substances, placed in situations by which transmission of light through them is intercepted, exhibit no color, but become entirely black."

The art of dyeing, therefore, (according to Mr. Delaval,) "consists principally in covering white substances, from which light is strongly reflected, with transparent colored media, which, according to their several colors, transmit more or less copiously the rays reflected from the white," since "the transparent media themselves reflect no light; and it is evident that if they yielded their colors by reflecting, instead of transmitting the rays, the whiteness or color of the ground on which they are applied, would not in any-wise alter or affect the colors which they exhibit."

But when any opaque basis is interposed, the reflection is doubtless made by it, rather than by the substance of the dyed wool, silk, &c., and more especially when such basis consists of the white earth of alum, or the white oxyde of tin; which, by their strong reflective powers, greatly augment the lustre of colors. There are, moreover, some opaque coloring matters, particularly the acetous, and other solutions of iron, used to stain linen, cotton, &c., which must necessarily themselves reflect, instead of transmitting the light by which their colors are made perceptible.

The compound or mixed colors, are such as result from the combination of two differently colored dye stuffs, or from dyeing stuffs with one color, and then with another. The simple colors of the dyer are red, yellow, blue, and black, with which, when skilfully blended, he can produce every variety of tint. Perhaps the dun or fawn color might be added to the above, as it is directly obtained from a great many vegetable substances.

1. Red with yellow, produces orange; a color which, upon wool, is given usually with the spent scarlet bath. To this shade may be referred flame color, pomegranate, capuchin, prawn, jonquil, *cassis*, chamois, *café au lait*, aurora, marigold, orange peel, *mordorés*, cinnamon, gold, &c. Snuff, chestnut, musk, and other shades are produced by substituting walnut peels or sumach for bright yellow. If a little blue be added to orange, an olive is obtained. The only direct orange dyes are annotto, and subchromate of lead; see Silk and Wool Dyeing.

2. Red with blue produces purple, violet, lilach, pigeon's neck, mallow, peach-blossom, *bleu de roi*, lint-blossom, amaranth.

3. Red with black; brown, chocolate, marone, &c.

4. Yellow with blue; green of a great variety of shades, such as nascent green, gay green, grass green, spring green, laurel green, sea green, celadon green, parrot green, cabbage green, apple green, duck green.

5. Mixtures of colors, three and three, and four and four, produce an indefinite diversity of tints; thus red, yellow, and blue, form brown olives, and greenish grays; in which the blue dye ought always to be first given, lest the indigo vat should be soiled by other colors. Red, yellow, and gray, (which is a gradation of black,) give the dead-leaf tint, as well as dark orange, snuff color, &c. Red, blue, and gray, give a vast variety of shades; as lead gray, slate gray, wood-pigeon gray, and other colors, too numerous to specify. See Brown Dye.

The following list of dyes, and the coloring substances which produce them, may prove useful.

Red. Cochineal, kermes, lac, madder, archil, carthamus or safflower, brazil wood, logwood, periodide of mercury, alkanet.

Yellow. Quercitron, weld, fustic, (yellow wood,) annotto, sawwort, dyer's broom, turmeric, fustet, (*rhus cotinus*,) Persian and Avignon berries, (*rhamnus infectorius*,) willow, peroxyde of iron; chromate of lead, (chrome yellow,) sulphuret of arsenic, hydrosulphuret of antimony; nitric acid on silk.

Blue. Indigo, woad or pastel, Prussian blue, turnsole or litmus, logwood with a salt of copper.

Galls, sumach, logwood, walnut peels, and other vegetables which contain
d gallic acid, along with ferruginous mordants.   The anacardium of India.

These are produced by the blue and yellow dyes skilfully combined; with the
of the chrome green, and perhaps the copper green of Schweinfurt.

.   Annotto, and mixtures of red and yellow dyes; subchromate of lead.

See the remarks at the beginning of this article; BROWN in its alphabetical
ₗLICO PRINTING, CATECHU, and MANGANESE.

Dun, or *Root*.   Walnut peels,. sumach, birch-tree, henna, sandal wood.   See
ᵣINTING, for a great variety of these dyes.

64 and 365 represent in a cross and longitudinal section the automatic dyeing
per, so generally employed in the well-appointed factories of Lancashire.
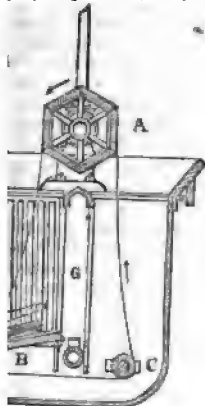
A is the long reel, composed at each end of six
radial iron arms or spokes, bound at their outer ex-
tremities with a six-sided wooden frame; these two
terminal hexagons are connected by long wooden
laths, seen above and below A in *fig.* 365. ᵣ shows
the sloping border or ledge of the copper. B and c
are rollers laid horizontally, for facilitating the con-
tinuous motion of the series of pieces of goods
stitched together into an endless web, which are
made to travel by the incessant rotations of the reel.
Immediately above the roller B in *fig.* 364, all the
spare foldings of the web are seen resting upon the
sloping wooden grating, which guides them onwards
in the direction indicated by the arrow.   The dye
stuffs are put within the middle grating, like a hen-
coop, marked G.   Each copper is 6 feet long, 3½ feet
wide, 3½ feet deep, exclusive of the top ledge, 9
inches high.   Such steam coppers are usually erected
in pairs, and moved by a common horizontal bevel
wheel seen at D in *fig.* 365, fixed upon a vertical shaft,

365
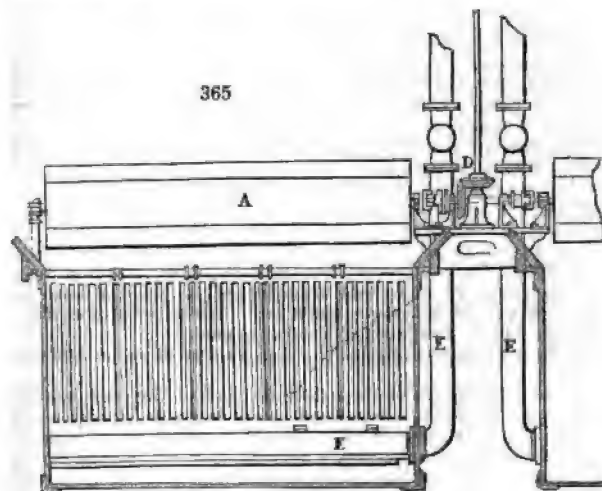
ₒ gear by a wheel at its top, with one of the driving shafts of the factory.   Upon
of D, the two steam pipes for supplying the right and left hand coppers are
h provided with a stop cock for admitting, regulating, or cutting off the steam.
am pipes descend at E E, the horizontal branch having several orifices in its
face.   The horizontal shaft in a line with the axes of the reels, and which
ₗ, is furnished upon each side with a clutch for putting either of the reels into
ₐear, that is to say, setting it a going, or at rest, in a moment by the touch of a
er.

am pipe of distribution E lies horizontally near the bottom of the middle coop,
under G in *fig.* 364, and sends up the steam through its numerous orifices,
ₑ dye-stuffs and water by which it is covered.   Thus the infusion or decoc-

tion is continually advancing in the copper, during the incessant loco-motion of the end-less web. The horizontal pipe traverses the copper from end to end, and is not stopped short in the middle. Each of these coppers can receive two, three, or more parallel pieces of goods at a time, the reel and copper being divided into so many compartments by trans-verse wooden spars.

E.

EARTHS. (*Terres*, Fr.; *Erden*, Germ.) Modern science has demonstrated that the substances called primitive earths, and which prior to the great electro-chemical career of Sir H. Davy, were deemed to be elementary matter, are all compounds of certain metallic bases and oxygen, with the exception of silica, whose base, silicon, being analo-gous to boron, has led that compound to be regarded as an acid; a title characteristic of the part it extensively performs in neutralizing alkaline bodies, in mineral nature, and in the processes of art. Four of the earths, when pure, possess decided alkaline properties, being more or less soluble in water, having (at least three of them) an acrid alkaline taste, changing the purple infusion of red cabbage to green, most readily satu-rating the acids, and affording thereby neutro-saline crystals. These four are *baryta*, *strontia*, *lime* (*calcia*), and *magnesia*. The earths proper are five in number; *alumina*, *glucina*, *yttria*, *zirconia*, and *thorina*. These do not change the color of infusion of cab-bage or tincture of litmus, do not readily neutralize acidity, and are quite insoluble in water. The alkalis are soluble in water, even when carbonated; a property which dis-tinguishes them from the alkaline earths. *Lithia* must for this reason be considered to be an alkali. See the above substances in their alphabetical places.

EAU DE COLOGNE. This preparation has long possessed great celebrity, in con-sequence chiefly of the numerous virtues ascribed to it by its venders; and is resorted to by many votaries of fashion as a panacea against ailments of every kind. It is however nothing more than aromatized alcohol, and as such, an agreeable companion of the toilet. Numerous fictitious recipes have been offered for preparing *eau de Cologne;* the fol-lowing may be reckoned authentic, having been imparted by Farina himself to a friend.

Take 60 gallons of silent brandy; sage, and thyme, each 6 drachms; balm-mint and spearmint, each 12 ounces; calamus aromaticus, 4 drachms; root of angelica, 2 drachms; camphor, 1 drachm; petals of roses and violets, each 4 ounces; flowers of lavender, 2 ounces; flowers of orange, 4 drachms; wormwood, 1 ounce; nutmegs, cloves, cassia lignea, mace, each 4 drachms. Two oranges and two lemons, cut in pieces. Allow the whole to macerate in the spirit during 24 hours, then distil off 40 gallons by the heat of a water bath. Add to the product:

Essence of lemons, of cedrat, of balm-mint, of lavender, each 1 ounce 4 drachms; neroli and essence of the seed of anthos, each 4 drachms; essence of jasmin, 1 ounce; of bergamot, 12 ounces. Filter and preserve for use.

Cadet Gassincourt has proposed to prepare *eau de Cologne* by the following recipe: Take alcohol at 32° B., 2 quarts; neroli, essence of cedrat, of orange, of lemon, of ber-gamot, of rosemary, each 24 drops; add 2 drachms of the seeds of lesser cardamoms, distil by the heat of a water bath a pint and a half. When prepared as thus by simple mixture of essences without distillation, it is never so good.

EAU DE LUCE is a compound formed of the distilled oil of amber and water of am-monia.

ELEMI is a resin which exudes from incisions made during dry weather through the bark of the *amyris elemifera*, a tree which grows in South America and Brazil. It comes to us in yellow, tender, transparent lumps, which readily soften by the heat of the hand. They have a strong aromatic odor, a hot spicy taste, and contain 12½ per cent. of ethereous oil. The crystalline resin of elemi has been called *Elemine*. It is used in ma-king lacker, to give toughness to the varnish.

EBULLITION. (Eng. and Fr.; *Kochen*, Germ.) When the bottom of an open vessel containing water is exposed to heat, the lowest stratum of fluid immediately expands, becomes therefore specifically lighter, and is forced upwards by the superior grav-ity of the superincumbent colder and heavier particles. The heat is in this way diffused through the whole liquid mass, not by simple communication of that power from par-ticle to particle as in solids, called the *conduction* of caloric, but by a translation of the several particles from the bottom to the top, and the top to the bottom, in alternate succession. This is denominated the *carrying* power of fluids, being common to both liquid and gaseous bodies. These internal movements may be rendered very conspi-cuous and instructive, by mingling a little powdered amber with water, contained in a

all glass cylinder, standing upon a sand-bath. A column of the heated and lighter particles will be seen ascending near the axis of the cylinder, surrounded by a hollow column of the cooler ones descending near the sides. That this molecular translation x locomotion is almost the sole mode in which fluids get heated, may be demonstrated by placing the middle of a pretty long glass tube, nearly filled with water, obliquely over an argand flame. The upper half of the liquid will soon boil, but the portion under he middle will continue cool, so that a lump of ice may remain for a considerable time at he bottom. When the heat is rapidly applied, the liquid is thrown into agitation, in consequence of elastic vapor being suddenly generated at the bottom of the vessel, and being as suddenly condensed at a little distance above it by the surrounding cold columns. These alternate expansions and contractions of volume become more manifest as the liquid becomes hotter, and constitute the *simmering* vibratory sound which is the prelude of ebullition. The whole mass being now heated to a pitch compatible with its permanent elasticity, becomes turbulent and explosive under the continued influence of fire, and emitting more or less copious volumes of vapor, is said to boil. The further elevation of temperature, by the influence of caloric, becomes impossible in these circumstances with almost all liquids, because the vapor carries off from them as much heat in a latent state as they are capable of receiving from the fire.

The temperature at which liquids boil in the open air varies with the degree of atmospheric pressure, being higher as that is increased, and lower as it is diminished. Hence boiling water is colder by some degrees in bad weather, or in an elevated situation, with depressed barometer, than in fine weather, or at the bottom of a coal-pit, when the barometer is elevated. A high column of liquid, also, by resisting the discharge of the steam, raises the boiling point. In *vacuo*, all liquids boil at a temperature about 24° F. lower than under the average atmospheric pressure. For a table of elasticities, see VAPOR. Gay Lussac has shown that liquids are converted into vapors more readily, or with less turbulence, when they are in contact with angular or irregular, than with smooth surfaces; that they therefore boil at a heat 2° F. lower in metallic than in glass vessels, probably owing to the greater polish of the latter. For example, if into water about to boil in a glass matrass, iron filings, ground glass, or any other insoluble powder be thrown, such a brisk ebullition will be instantly determined as will sometimes throw the water out of the vessel; the temperature at the same time sinking two degrees F. It would thence appear that the power of caloric, like that of electricity, becomes concentrated by points.

The following table exhibits the boiling heats, by Fahrenheit's scale, of the most important liquids :—

Ether, specific gravity 0·7365 at 48°	-	-	-	-	-	-	-	100°
Carburet of sulphur	-	-	-	-	-	-	-	113
Alcohol, sp. grav. 0·813 -	-	-	-	Ure	-	-	-	173·5
Nitric acid,	1·500 -	-	-	-	Dalton	-	-	-	210
Water	-	-	-	-	-	-	-	-	212
Saturated solution of Glauber salt	-	-	Biot	-	-	-	213½
do.	do.	Acetate of lead	-	-	do.	-	-	-	215¾
do.	do.	Sea salt	-	-	-	do.	-	-	-	224½
do.	do.	Muriate of lime,	-	-	Ure	-	-	-	285
do.	do.	do.	1 + water 2,	do.	-	-	-	230
do.	do.	do.	35·5 + do. 64·5, do.	-	-	-	235
do.	do.	do.	40·5 + do. 59·5, do.	-	-	-	240
Muriatic acid, sp. gr. 1·094	-	-	-	Dalton	-	-	-	232
do.	do.	1·127	-	-	-	do.	-	-	-	222
Nitric acid,	do.	1·420	-	-	-	do.	-	-	-	248
do.	do.	1·30	-	-	-	do.	-	-	-	236
Rectified petroleum	-	-	-	Ure	-	-	-	306
Oil of turpentine	-	-	-	do.	-	-	-	316
Sulphuric acid, sp. gr. 1·848	-	-	-	Dalton	-	-	-	600
do.	do.	1·810	-	-	-	do.	-	-	-	473
do.	do.	1·780	-	-	-	do.	-	-	-	435
do.	do.	1·700	-	-	-	do.	-	-	-	374
do.	do.	1·650	-	-	-	do.	-	-	-	350
do.	do.	1·520	-	-	-	do.	-	-	-	290
do.	do.	1·408	-	-	-	do.	-	-	-	260
do.	do.	1·300 +	-	-	-	do.	-	-	-	240
Phosphorus	-	-	-	-	-	do.	-	-	-	554
Sulphur -	-	-	-	-	-	do.	-	-	-	570
Linseed oil	-	-	-	-	-	do.	-	-	-	640

Mercury -	- - - - -		Dulong	- 662°
do.	- - - - -		Crighton	- 656
Saturated solution of acetate of soda, containing 60 per cent.			Griffiths	- 256
do.	Nitrate of soda,	60	do.	- 246
do.	Rochelle salt,	90	do.	- 240
do.	Nitre,	74	do.	- 238
do.	Muriate of ammonia,	50	do.	- 226
do.	Tartrate of potash,	68	do.	- 234
do.	Muriate of soda,	30	do.	- 224
do.	Sulphate of magnesia,	57·5	do.	- 222
do.	Borax,	52·5	do.	- 222
do.	Phosphate of soda,	?	do.	- 222
do.	Carbonate of soda,	?	do.	- 220
do.	Alum,	52	do.	- 220
do.	Chlorate of potash,	40	do.	- 218
do.	Sulphate of copper,	45	do.	- 216

EDULCORATE (*Edulcorer*, Fr.; *Aussüssen*, Germ.) is a word introduced by the alchemists to signify the sweetening, or rather rendering insipid, of acrimonious pulverulent substances, by copious ablutions with water. It means, in modern language, the washing away of all particles soluble in water, by agitation or trituration with this fluid, and subsequent decantation or filtration.

EFFERVESCENCE. (Eng. and Fr.; *Aufbrausen*, Germ.) When gaseous matter is suddenly extricated with a hissing sound during a chemical mixture, or by the application of a chemical solvent to a solid, the phenomenon, from its resemblance to that of simmering or boiling water, is called effervescence. The most familiar example is afforded in the solution of sodaic powders; in which the carbonic acid gas of sesqui-carbonate of soda is extricated by the action of citric or tartaric acid.

EFFLORESCENCE (Eng. and Fr.; *Verwittern*, Germ.) is the spontaneous conversion of a solid, usually crystalline, into a powder, in consequence either of the abstraction of the combined water by the air, as happens to the crystals of sulphate and carbonate of soda; or by the absorption of oxygen and the formation of a saline compound, as in the case of alum schist, and iron pyrites. Saltpetre appears as an efflorescence upon the ground and walls in many situations.

EDGE-TOOLS. See CUTLERY and STEEL.

EGGS, HATCHING. See INCUBATION, ARTIFICIAL.

EIDER-DOWN is a kind of precious down, so called because it is obtained from the *Eider*-duck. These birds build their nests among precipitous rocks, and the female lines them with fine feathers plucked from her breast, among which she lays her five eggs. The natives of the districts frequented by the eider-ducks let themselves down by cords among the dangerous cliffs, to collect the down from the nests. It is used to fill coverlets, pillows, cushions, &c.

ELAINE is the name given by Chevreul to the thin oil which may be expelled from tallow, and other fats, solid or fluid, by pressure either in their natural state, or after being saponified, so as to harden the *stearine*. It may be extracted also by digesting the fat in 7 or 8 times its weight of boiling alcohol, spec. grav. 0·798, till it dissolves the whole. Upon cooling the solution, the stearine falls to the bottom, while the elaine collects in a layer like olive oil, upon the surface of the supernatant solution, reduced by evaporation to one eighth of its bulk. If this elaine be now exposed to a cold temperature, it will deposite its remaining stearine, and become pure. See FAT, OILS, and STEARINE.

ELASTIC BANDS. (*Tissus Elastiques*, Fr.; *Federharz-zeige*, Germ.) The manufacture of braces and garters, with threads of caoutchouc, either naked or covered, seems to have originated, some time ago, in Vienna, whence it was a few years since imported into Paris, and thence into this country. At first the pear-shaped bottle of Indian rubber was cut into long narrow strips by the scissors; a single operative turning off only about 100 yards in a day, by cutting the pear in a spiral direction. He succeeded next in separating with a pair of pincers the several layers of which the bottle was composed. Another mode of obtaining fine threads was to cut them out of a bottle which had been rendered thin by inflation with a forcing pump. All these operations are facilitated by previously steeping the caoutchouc in boiling water, in its moderately inflated state. More recently, machines have been successfully employed for cutting out these filaments, but for this purpose the bottle of caoutchouc is transformed into a disc of equal thickness in all its parts, and perfectly circular. This preliminary operation is executed as follows: 1. the bottle, softened in hot water, is squeezed between the two plates of a press, the neck having been removed beforehand, as useless in this point of view; 2. the bottle is then cut into two equal parts, and is allowed to con-

solidate by cooling before subjecting it to the cutting instrument. When the bottle is strong enough, and of variable thickness in its different points, each half is submitted to powerful pressure in a very strong cylindrical mould of metal, into which a metallic plunger descends, which forces the caoutchouc to take the form of a flat cylinder with a circular base. The mould is plunged into hot water during the compression. A stem or rod of iron, which goes across the hollow mould and piston, retains the latter in its place, notwithstanding the resilience of the caoutchouc, when the mould is taken from the press. The mould being then cooled in water, the caoutchouc is withdrawn.

The transformation of the disc of caoutchouc into fine threads is performed by two machines; the first of which cuts it into a riband of equal thickness in its whole extent, running in a spiral direction from the circumference to the centre; the second subdivides this riband lengthwise into several parallel filaments much narrower but equally thick.

The following *figs.* 366, 367, 368, represent the machine for cutting the spiral riband. The disc D, placed horizontally, turns round its vertical axis, so as to present its

366

367

368
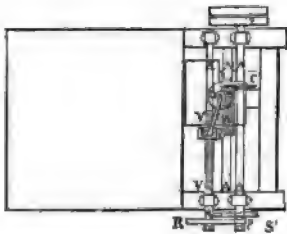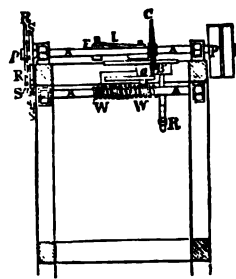
periphery to the edge of a knife c, formed like a circular blade, whose plane is perpendicular to that of the bases of the disc. This knife turns round its centre, which is fixed. The rotatory motion of the disc forces the knife to penetrate further and further into its mass, and the motion of the knife itself makes it cut the riband more easily. It is obvious, that if the disc alone revolve, the motionless knife could act only by pressure, and would meet with an enormous resistance. A third movement becomes necessary. In proportion as the disc is diminished by the removal of the spiral band, the centre of this disc must advance upon the knife, in order that the riband may have always the same breadth. The inspection of *fig.* 368 will make the accordance of the three motions intelligible.

The knife c is placed upon a shaft or axis A, which carries a pulley, round which a belt or cord runs which drives the whole machine. This knife is six inches in diameter. In order that by being kept cool it may cut the caoutchouc better, it is plunged at its lower part into a trough B, full of water; a stopcock R, serves to empty this trough.

The shaft A bears a pinion p, which takes into a wheel R, placed upon the shaft A′; upon which there is cut a worm or endless screw, v, v. This worm bears a nut E, which advances as the screw turns, and carries with it a tie L, which in its turn pushes the disc D, carried upon a shoulder constantly towards the knife. This shoulder is guided by two ears which slide in two grooves cut in the thickness of the table. The diameter of the pinion p is about one fifth of that of the wheel R; so that the arbor A turns five times less quickly than the arbor A′; and the fineness of the screw v contributes further to slacken the movement of translation of the disc.

When the disc is all cut down, the shoulder, the tie, and the nut, are brought back to their original position by lifting the nut, which is hinged on. The disc is fixed upon the shoulder by means of sharp points, and an upper washer. The shoulder and the washer have a very small diameter, in order that the knife may, in cutting down the disc, advance as near as possible to the centre.

The rotatory movement of the disc and its shoulder, is given by an endless screw w, w, which governs a pinion p′, provided with 10 teeth, and carried by the shaft A, upon which the shoulder is mounted. The arbor A′ of this endless screw receives its motion from the first shaft A, by means of the wheels s and s′ mounted upon these shafts, and of an intermediate wheel s″. This wheel, of a diameter equal to that of the shaft A″, is intended merely to allow this shaft to recede from the shaft A. The diameter of the wheel of this last shaft is to that of the two others in the ratio of 10 to 8.

Second machine for subdividing the ribands. Fig. 369.—The riband is engaged between the circular knives, c, c, which are mounted upon the rollers n, n ; thin brass washers keep these knives apart at a distance which may be varied, and two extreme washers mounted with screws on each roller maintain the whole system. The axes of these rollers traverse two uprights m, m, furnished with brasses, and with adjusting screws to approximate them at pleasure. The axis of the lower roller carries a wheel

369
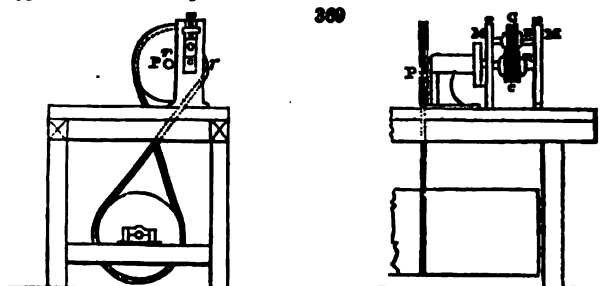
r, which takes into another smaller wheel r', placed upon the same shaft as the pulley r, which is driven by a cord. The diameter of the wheel r is three times greater than the wheel r'. The pulley r is twice the size of the wheel r' ; and its cord passes round a drum n, which drives the rest of the machine.

The threads, when brought to this state of slenderness, are put successively into tubs filled with cold water; they are next softened in hot water, and elongated as much as possible in the following manner:—They are wound upon a reel turned quickly, while the operative stretches the caoutchouc thread with his hand. In this way it is rendered 8 or 10 times longer. The reels when thus filled are placed during some days in a cold apartment, where the threads become firm, and seem to change their nature.

This state of stiffness is essential for the success of the subsequent operations. The threads are commonly covered with a sheath of silk, cotton, or linen, by a braiding machine, and are then placed as warp in a loom, in order to form a narrow web for braces, garters, &c. If the gum were to exercise its elasticity during this operation, the different threads would be lengthened and shortened in an irregular manner, so as to form a puckered tissue. It is requisite therefore to weave the threads in their rigid and inextensible, or at least incontractile condition, and after the fabric is woven to restore to the threads of caoutchouc their appropriate elasticity. This restoration is easily effected by passing a hot smoothing iron over the tissue laid smoothly upon a table covered with blanket stuff. See BRAIDING MACHINE.

ELECTIVE AFFINITY (*Wahlverwandtschaft*, Germ.) denotes the order of preference, so to speak, in which the several chemical substances *choose* to combine; or really, the gradation of attractive force infused by Almighty Wisdom among the different objects of nature, which determines perfect uniformity and identity in their compounds amidst indefinite variety of combination. The discussion of this interesting subject belongs to pure chemistry. See DECOMPOSITION.

ELEMENTS, (Eng. and Fr.; *Grundstoffe*, Germ.) The ancients considered fire, air, water, and earth, as simple substances, essential to the constitution of all terrestrial beings. This hypothesis, evidently incompatible with modern chemical discovery, may be supposed to correspond, however, to the four states in which matter seems to exist; namely, 1. the unconfinable, powers of fluids—caloric, light, electricity ; 2. ponderable gases, or elastic fluids ; 3. liquids ; 4. solids. The three elements of the alchemists, salt, earth, mercury, were, in *their* sense of the word, mere phantasms.

In modern science, the term *Element* signifies merely a substance which has not yet been resolved by analysis into any simple form of matter; and it is therefore synonymous with undecompounded. This class comprehends 54 different bodies, of which no less than 41 are metallic. Five may be styled *Archæal*, from the intensity and universality of their affinities for the other bodies, which they penetrate, corrode, and apparently consume, with the phenomena of light and heat. These 5 are *chlorine, oxygen, iodine, bromine, fluorine.* Eight elements are eminently inflammable when acted upon by any of the preceding five, and are thereby converted into incombustible compounds. The simple non-metallic inflammables are *hydrogen, azote, sulphur, phosphorus, selenium, carbon, boron, silicon.*

The following table exhibits all the undecompounded bodies in alphabetical order, with their prime equivalent numbers, atomic weights, or reciprocal combining and saturating proportions, as given by Berzelius, in reference to oxygen, reckoned 100,000 : —

Table of undecompounded Bodies, or modern Chemical Elements.

A signifies Archæal ; I, Inflammable ; M, Metal.

m	M.	.	.	171,167	Mercury	M.	.	.	1265,822
oy	—	.	.	806,542	Molybdenum	—	.	.	598,525
:	—	.	.	470,012	Nickel	—	.	.	369,675
	I.	.	.	88,518	Osmium	—	.	.	1244,210
	M.	.	.	856,880	Oxygen	A.	.	.	100,000
1	—	.	.	886,000	Palladium	M.	.	.	665,840
	I.	.	.	135,983	Phosphorus	I.	.	.	196,155
e	A.	.	.	489,150	Platinum	M.	.	.	1233,260
m	M.	.	.	696,970	Rhodium	—	.	• .	651,400
1	—	.	.	256,019	Selenium	I.	.	.	494,582
	I.	.	.	76,437	Silicon	—	.	.	277,478
	M.	.	.	574,718	Silver	M.	.	.	675,804
e	A.	.	.	221,325	Strontium	—	.	.	547,285
am	M.	.	.	351,819	Sulphur	I.	.	.	201,165
	—	.	.	369,991	Tantalum	M.	.	.	153,715
	—	.	.	395,695	Tellurium	—	.	.	801,760
e	I.	.	.	116,900	Thorinum	—	.	.	744,900
	M.	.	.	1243,013	Tin	—	.	.	735,294
en	I.	.	.	62,398	Titanium	—	.	.	803,686
	A.	.	.	789,145	Tungsten	—	.	.	1183,000
.	M.	.	.	1233,260	Uranium	—	.	.	2711,360
	—	.	.	339,213	Vanadium	—	.	.	855,840
	—	.	.	1294,489	Yttrium	—	.	.	401,840
a	—	.	.	81,320	Zinc	—	.	.	403,226
sium	—	.	.	158,353	Zirconium	—	.	.	420,238
nesium	—	.	.	345,900					

'TRIATE. (*Soutirer*, Fr.; *Schlemmen*, Germ.)　When an insoluble pulverulent like whitening or ground flints, is diffused through a large body of water, and the ɛ is allowed to settle for a little, the larger particles will subside.　If the supernaʲuid be now carefully decanted, or run off, with a syphon, it will contain an imle powder, which on repose will collect at the bottom, and may be taken out to dry. rocess is called elutriation.

BALMING (*Embaument*, Fr.; *Einbalsamen*, Germ.) is an operation in which ɛ (*baumes*, Fr.) were employed to preserve human corpses from putrefaction; ɛ the name.

ancient Egyptians had recourse to this process for preserving the bodies of numernilies, and even of the animals which they loved or worshipped.　An excellent t of their methods is given in Mr. Pettigrew's work upon Mummies.　Modern try has made us acquainted with many means of counteracting putrefaction more and efficacious than the Egyptian system of salting, smoking, spicing, and bituɔg.　See PUTREFACTION.

BOSSING WOOD. (*Bossage*, Fr.; *Erhabenes Arbeit*, Germ.)　Raised figures upon such as are employed in picture frames and other articles of ornamental cabinet are usually produced by means of carving, or by casting the pattern in plaster of or other composition, and cementing, or otherwise fixing it on the surface of the

　The former mode is expensive; the latter is inapplicable on many occasions. nvention of Mr. Streaker may be used either by itself, or in aid of carving; and ls on the fact, that if a depression be made by a blunt instrument on the surface of ɔd, such depressed part will again rise to its original level by subsequent immersion water.

· wood to be ornamented having been first worked out to its proposed shape, is in a ɔ receive the drawing of the pattern; this being put on, a blunt steel tool, or burnor die, is to be applied successively to all those parts of the pattern intended to be ɛf, and, at the same time, is to be driven very cautiously, without breaking the of the wood, till the depth of the depression is equal to the intended prominence figures.　The ground is then to be reduced by planing or filing to the level of the ɛed part; after which, the piece of wood being placed in water, either hot or cold, ɾt previously depressed will rise to its former height, and will then form an embossed a, which may be finished by the usual operations of carving.

this invention the Society of Arts voted to Mr. Streaker their silver Isis medal and ɩineas.

BOSSING CLOTH.　Mr. Thomas Greig, of Rose Bank, near Bury, patented 'ention, in November, 1835, which consists in an ingenious construction of machinery

for both embossing and printing silk, cotton, woollen cloth, paper, and other fabrics, in one or more colors, at one operation.

Figs. 370, 370* represent three distinct printing cylinders of copper, or other suitable material, A, B, C, with their necessary appendages for printing three different colors upon the fabric as it passes through the machine: either of these cylinders A, B, or C, may be employed as an embossing cylinder, without performing the printing process, or may be made to effect both operations at the same time.
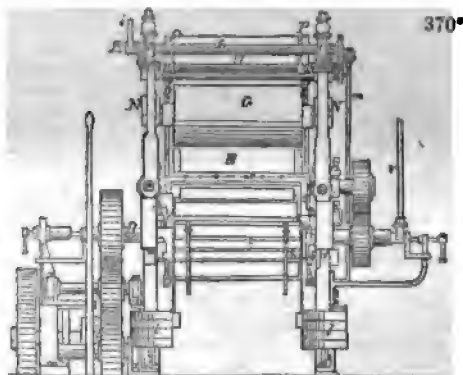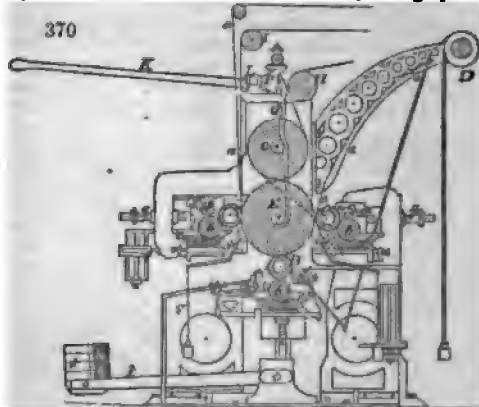
The fabric or goods to be operated upon being first wound tightly upon a roller, that roller is to be mounted upon an axle or pivot, bearing in arms or brackets at the back of the machine, as shown at D. From this roller the fabric *a a a a* is conducted between tension rails, and passed under the bed cylinder or paper bowl E, and from thence proceeds over a carrier roller F, and over steam boxes not shown in the drawing, or it may be conducted into a hot room, for the purpose of drying the colors.

The cylinders A, B, and C, having neither engraved or raised surfaces, are connected to feeding rollers *b b b*, revolving in the ink or colored troughs *c c c;* or endless felts, called sieves, may be employed, as in ordinary printing machines, for supplying the color, when the device on the surface of the cylinders is raised: these cylinders may be furnished with doctors or scrapers when required, or the same may be applied to the endless felts.

The blocks have adjustable screws *g g*, for the purpose of bringing the cylinders up against the paper bowl, with any required degree of pressure: the cylinder B is supported by its gudgeons running in blocks, which blocks slide in the lower parts of the side frames, and are connected to perpendicular rods *i*, having adjustable screw nuts.

The lower parts of these rods bear upon weighted levers *k k*, extending in front of the machine; and by increasing the weights *l l*, any degree of upward pressure may be given to the cylinder B.

The color boxes or troughs *c c c*, carrying the feeding rollers *b b b*, are fixed on boards which slide in grooves in the side frames, and the rollers are adjusted and brought into contact with the surface of the printing cylinders by screws.

If a back cloth should be required to be introduced between the cylindrical bed or paper bowl E, and the fabric *a a a*, as the ordinary felt or blanket, it may, for printing and embossing cotton, silk, or paper, be of linen or cotton; but if woollen goods are to be operated upon, a cap of felt, or some such material, must be bound round the paper bowl, and the felt or blanket must be used for the back cloth, which is to be conducted over the rollers H and I.

For the purpose of embossing the fabric, either of the rollers A, B, or C, may be

employed, observing that the surface of the roller must be cut, so as to leave the pattern or device elevated for embossing velvets, plain cloths, and papers; but for woollens the device must be excavated, that is, cut in recess.

The pattern of the embossing cylinder will, by the operation, be partially marked through the fabric on to the surface of the paper bowl E; to obliterate which marks from the surface of the bowl, as it revolves, the iron cylinder roller G is employed; but as in the embossing of the same patterns on paper, a counter roller is required to produce the pattern perfectly, the iron roller is in that case dispensed with, the impression given to the paper bowl being required to be retained on its surface until the operation is finished.

In this case the relative circumferences of the embossing cylinder, and of the paper bowl, must be exactly proportioned to each other; that is, the circumference of the bowl must be equal, exactly, to a given number of circumferences of the embossing cylinder, very accurately measured, in order to preserve a perfect register or coincidence, as they continue revolving between the pattern on the surface of the embossing cylinder, and that indented into the surface of the paper bowl.

The axle of the paper bowl E, turns in brasses fitted into slots in the side frames, and it may be raised by hand from its bearings when required, by a lever k, extending in front. This lever is affixed to the end of a horizontal shaft L, L, crossing the machine seen in the figures, at the back of which shaft there are two segment levers P, P, to which bent rods Q, Q, are attached, having hooks at their lower ends, passed under the axle of the bowl. At the reverse end of the shaft L, a ratchet-wheel r, is affixed, and a pall or click mounted on the side of the frame takes into the teeth of the wheel r, and thereby holds up the paper bowl when required.

When the iron roller G, is to be brought into operation, the vertical screws t, t, mounted in the upper parts of the side frames, are turned, in order to bring down the brasses N, which carry the axle of that roller and slide in the side frames.

The cylinders A, B, and C, are represented hollow, and may be kept at any desired temperature during the operation of printing, by introducing steam into them; and under the color boxes c, c, c, hollow chambers are also made for the same purpose. The degree of temperature required to be given to these must depend upon the nature of the coloring material, and of the goods operated upon. For the purpose of conducting steam to these hollow cylinders and color boxes, pipes, as shown at v, v, v, are attached, which lead from a steam boiler. But when either of these cylinders is employed for embossing alone, or for embossing and printing at the same time, and particularly for some kinds of goods where a higher temperature may be required, a red-hot heater is then introduced into the hollow cylinder in place of steam.

If the cylinder B is employed as the embossing cylinder, and it is not intended to print the fabric by that cylinder simultaneously with the operation of embossing, the feeding roller b, must be removed, and also the color box c, belonging to that cylinder; and the cylinders A and c, are to be employed for printing the fabric, the one applying the color before the embossing is effected, the other after it. It is however to be remarked, that if A, and c, are to print colors on the fabric, and B to emboss it, in that case it is preferred, where the pattern would allow it. A and c, are wooden rollers having the pattern upon their surfaces, and not metal, as the embossing cylinders must of necessity be.

It will be perceived that this machine will print one, two, or three colors at the same time, and that the operation of embossing may be performed simultaneously with the printing, by either of the cylinders A, B, or c, or the operation may be performed consecutively by the cylinders, either preceding or succeeding each other.

The situations of the doctors, when required to be used for removing any superfluous color from the surface of the printing cylinder, are shown at d, d, d; those for removing any lint which may attach itself, at e, e, e. They are kept in their bearings by weighted levers and screws, and receive a slight lateral movement to and fro, by means of the vertical rod m, which is connected at top to an eccentric, on the end of the axle of the roller H, and at its lower end to a horizontal rod mounted at the side of the frame; to this horizontal rod, arms are attached, which are connected to the respective doctors; and thus, by the rotation of the eccentric, the doctors are made to slide laterally.

When the cylinders A, B, or c, are employed for embossing only, those doctors will not be required. The driving power is communicated to the machine from any first mover through the agency of the toothed gear, which gives rotatory motion to the cylinder B, and from thence to the other cylinders A, and c, by toothed gear shown in *fig.* 370.

EMBROIDERING MACHINE. (*Machine à broder,* Fr.; *Steckmaschine,* Germ.) This art has been till of late merely a handicraft employment, cultivated on account of its elegance by ladies of rank. But a few years ago M. Heilmann of Mulhause invented a machine of a most ingenious kind, which enables a female to embroider any design with 80 or 140 needles as accurately and expeditiously as she formerly could do with one. A brief

account of this remarkable invention will therefore be acceptable to many readers. It was displayed at the national exposition of the products of industry in Paris for 1834, and was unquestionably the object which stood highest in public esteem; for whether at rest or in motion, it was always surrounded with a crowd of curious visiters, admiring the figures which it had formed, or inspecting its movements and investigating its mechanism. 130 needles were occupied in copying the same pattern with perfect regularity, all set in motion by one person.

Several of these machines are now mounted in France, Germany, and Switzerland. I have seen one factory in Manchester, where a great many of them are doing beautiful work.

The price of a machine having 130 needles, and of consequence 260 pincers or fingers and thumbs to lay hold of them, is 5000 francs, or 200*l.* sterling; and it is estimated to do daily the work of 15 expert hand embroiderers, employed upon the ordinary frame. It requires merely the labor of one grown-up person, and two assistant children. The operative must be well taught to use the machine, for he has many things to attend to; with the one hand he traces out, or rather follows the design with the point of the pantograph; with the other he turns a handle to plant and pull all the needles, which are seized by pincers and moved along by carriages, approaching to and receding from the web, rolling all the time along an iron railway; lastly, by means of two pedals, upon which he presses alternately with the one foot and the other, he opens the 130 pincers of the first carriage, which ought to give up the needles after planting them in the stuff, and he shuts with the same pressure the 130 pincers of the second carriage, which is to receive the needles, to draw them from the other side, and to bring them back again. The children have nothing else to do than to change the needles when all their threads are used, and to see that no needle misses its pincers.

This machine deserves particular attention, because it is no less remarkable for the happy arrangement of its parts, than for the effects which it produces. It may be described under four heads: 1. the structure of the frame; 2. the disposition of the web; 3. the arrangement of the carriages; and 4. the construction of the pincers.

1. The structure of the frame. It is composed of cast-iron, and is very massive. *Fig.* 371 exhibits a front elevation of it. The length of the machine depends upon the number of pincers to be worked. The model at the exposition had 260 pincers, and was 2 metres and a half (about 100 inches or 8 feet 4 inches English) long. The figure here given has been shortened considerably, but the other proportions are not disturbed. The breadth of the frame ought to be the same for every machine, whether it be long or short, for it is the breadth which determines the length of the thread to be put into the needles, and there is an advantage in giving it the full breadth of the model machine, fully 100 inches, so that the needles may carry a thread at least 40 inches long.

Disposition of the piece to be embroidered.—We have already stated that the pincers which hold the needles always present themselves opposite to the same point, and that in consequence they would continually pass oackwards and forwards through the same hole, but the piece is displaced with sufficient precision to bring opposite the tips progressively of the needles, every point upon which they are to work a design, such as a flower.

The piece is strained perpendicularly upon a large rectangular frame, whose four sides are visible in *fig.* 371; namely, the two vertical sides at F F, and the two horizontal sides, the upper and lower at F' F''. We see also in the figure two long wooden rollers G and G, whose ends, mounted with iron studs, are supported upon the sides F of the frame, so as to turn freely. These form a system of beams upon which the piece destined to receive the embroidery, is wound and kept vertically stretched to a proper degree, for each of these beams bears upon its end a small ratchet wheel g, g; the teeth of one of them being inclined in the opposite direction to those of the other. Besides this system of lower beams, there is another of two upper beams, which is however but imperfectly seen in the figure, on account of the interference of other parts in this view of the machine. One of these systems presents the web to the inferior needles, and the other to the upper needles. As the two beams are not in the same vertical plane, the plane of the web would be presented obliquely to the needles were it not for a straight bar of iron, round whose edge the cloth passes, and which renders it vertical. The piece is kept in tension crosswise by small brass templets, to which the strings g'' are attached, and by which it is pulled towards the sides of the frame F. It remains to show by what ingenious means this frame may be shifted in every possible direction. M. Heilmann has employed for this purpose the pantograph which draughtsmen use for reducing or enlarging their plans in determinate proportions.

b b' f b'' (*fig.* 371) represents a parallelogram of which the four angles b b', f b'', are jointed in such a way that they may become very acute or very obtuse at pleasure, while the sides of course continue of the same length; the sides b, b' and b, b'' are prolonged, the one to the point d, and the other to the point c, and these points c and d,

are chosen under the condition that in one of the positions of the parallelogram, the line $c\ d$ which joins them passes through the point f; this condition may be fulfilled in

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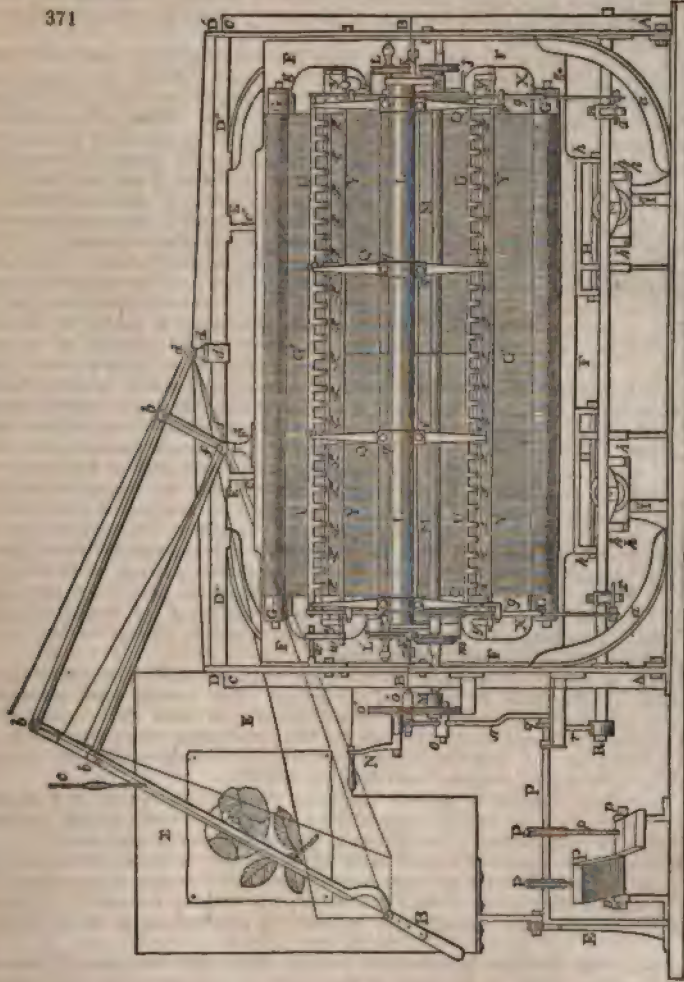
an infinite number of manners, since the position of the parallelogram remaining the same, we see that if we wished to shift the point d further from the point b', it would be sufficient to bring the point c near enough to b'', or *vice versa*; but when we have once fixed upon the distance $b'\ d$, it is evident that the distance $b''\ c$ is its necessary consequence. Now the principle upon which the construction of the pantograph rests is this; it is sufficient that the three points d, f, and c be in a straight line, in one only of the positions of the parallelogram, in order that they shall remain always in a straight line in every position which can possibly be given to it.

We see in the figure that the side $b\ c$, has a handle b'' with which the workman puts the machine in action. To obtain more precision and solidity in work, the sides of the pantograph are joined, so that the middle of their thickness lies exactly in the vertical plane of the piece of goods, and that the axes of the joints are truly perpendicular to this plane, in which consequently all the displacements are effected. We arrive at this result by making fast to the superior great cross bar D'' an elbow piece d'', having a suitable projection, and to which is adapted in its turn the piece d', which receives in a

socket the extremity of the side b, d; this piece d' is made fast to d'' by a bolt, but it carries an oblong hole, and before screwing up the nut, we make the piece advance or recede, till the fulcrum point comes exactly into the plane of the web. This condition being fulfilled, we have merely to attach the frame to the angle f of the parallelogram, which is done by means of the piece r''.

It is now obvious that if the embroiderer takes the handle r'' in his hand and makes the pantograph move in any direction whatever, the point f will describe a figure similar to the figure described by the point c, and six times smaller, but the point f cannot move without the frame, and whatever is upon it moving also. Thus, in the movement of the pantograph, every point of the web describes a figure equal to that described by the point f, and consequently similar to that described by the point c, but six times smaller; the embroidered object being produced upon the cloth in the position of that of the pattern. It is sufficient therefore to give the embroidering operative who holds the handle r'', a design six times greater than that to be executed by the machine, and to afford him at the same time a sure and easy means of tracing over with the point c, all the outlines of the pattern. For this purpose he adapts to c, perpendicularly to the plane of the parallelogram, a small style terminated by a point c', and he fixes the pattern upon a vertical tablet E, parallel to the plane of the stuff and the parallelogram, and distant from it only by the length of the style c c''; this tablet is carried by the iron rod e', which is secured to a cast iron foot r', serving also for other purposes, as we shall presently see. The frame loaded with its beams and its cloth forms a pretty heavy mass, and as it must not swerve from its plane, it needs to be lightened in order that the operative may cause the point of the pantograph to pass along the tablet without straining or uncertainty in its movements. M. Heilmann has accomplished these objects in the following way. A cord e attached to the side b c of the pantograph passes over a return pulley, and carries at its extremity, a weight which may be graduated at pleasure; this weight equipoises the pantograph, and tends slightly to raise the frame. The lower side of the frame carries two rods H and H, each attached by two arms h h, a little bent to the left; both of these are engaged in the grooves of a pulley. Through this mechanism a pressure can be exercised upon the frame from below upwards, which may be regulated at pleasure, and without preventing the frame from moving in all directions, it hinders it from deviating from the primitive plane to which the pantograph was adjusted. The length of the rods H ought to be equal to the amount of the lateral movement of the frame. Two guides i i carried by two legs of cast iron, present vertical slits in which the lower part of the frame r' is engaged.

Disposition of the carriages.—The two carriages, which are similar, are placed the one to the right, and the other to the left of the frame. The carriage itself is composed merely of a long hollow cylinder of cast iron L, carrying at either end a system of two grooved castors or pulleys L', which roll upon the horizontal rails K; the pulleys are mounted upon a forked piece l', with two ends to receive the axes of the pulleys, and the piece l' is itself bolted to a projecting ear l cast upon the cylinder.

This assemblage constitutes properly speaking the carriage, resting in a perfectly stable equilibrium upon the rails K, upon which it may be most easily moved backwards and forwards, carrying its train of needles to be passed or drawn through the cloth.

M. Heilmann has contrived a mechanism by which the operative without budging from his place may conduct the carriages, and regulate as he pleases the extent of their course, as well as the rapidity of their movements. By turning the axes M'' in the one direction or the other, the carriage may be made to approach to, or recede from the web.

When one of the carriages has advanced to prick the needles into the stuff, the other is there to receive them; it lays hold of them with its pincers, pulls them through, performs its course by withdrawing to stretch the thread, and close the stitch, then it goes back with the needles to make its pricks in return. During these movements the first carriage remains at its post waiting the return of the second. Thus the two chariots make in succession an advance and a return, but they never move together.

To effect these movements M. Heilmann has attached to the piece o' made fast to the two uprights A C and A D of the frame, a bent lever n o n'n'' moveable round the point o; the bend n' carries a toothed wheel o', and the extremity n'' a toothed wheel o''; the four wheels M M' o' and o'' have the same number of teeth and the same diameter; the two wheels o' and o'' are fixed in reference to each other, so that it is sufficient to turn the handle N to make the wheel o'' revolve, and consequently the wheel o'; when the lever n o is vertical, the wheel o' touches neither the wheel M nor the wheel M'; but if it be inclined to the one side or the other, it brings the wheel o' alternately into gear with the wheel M or the wheel M'. As the operative has his two hands occupied, the one with the pantograph and the other with the handle of impulsion, he has merely his feet for acting upon the lever n o, and as he has many other things to do, M. Heilmann has adapted before him a system of two pedals, by which he executes

with his feet a series of operations no less delicate than those which he executes with his hands.

The pedals P are moveable round the axis p, and carry cords p' wound in an opposite direction upon the pulleys P'; these pulleys are fixed upon a moveable shaft P'', supported upon one side by the prop E', and on the other in a piece K' attached to the two great uprights of the frame. In depressing the pedal P (now raised in the figure), the upper part of the shaft P'' will turn from the left to the right, and the lever n o will become inclined so as to carry the wheel o' upon the wheel M', but at the same time the pedal which is now depressed will be raised, because its cord will be forced to wind itself upon its pulley, as much as the other cord has unwound itself; and thus the apparatus will be ready to act in the opposite direction, when wanted.

Disposition of the pincers.—The shaft L' carries, at regular intervals of a semi-diameter, the appendages q q cast upon it, upon which are fixed, by two bolts, the curved branches Q destined to bear the whole mechanism of the pincers. When the pincers are opened by their appropriate leverage, and the half of the needle, which is pointed at each end, with the eye in the middle, enters the opening of its plate, it gets lodged in an angular groove, which is less deep than the needle is thick, so that when the pincers are closed, the upper jaw presses it into the groove. In this way the needle is firmly held, although touched in only three points of its circumference.

Suppose, now, that all the pincers are mounted and adjusted at their proper distances upon their prismatic bar, forming the upper range of the right carriage. For opening all the pincers there is a long plate of iron, U, capable of turning upon its axis, and which extends from the one end of the carriage to the other. This axis is carried by a kind of forks which are bolted to the extremity of the branches Q. By turning that axis the workman can open the pincers at pleasure, and they are again closed by springs. This movement is performed by his feet acting upon the pedals.

The threads get stretched in proportion as the carriage is run out, but as this tension has no elastic play, inconveniences might ensue which are prevented by adapting to the carriage a mechanism by means of which all the threads are pressed at the same time by a weight susceptible of graduation. A little beneath the prismatic bar, which carries the pincers, we see in the figure a shaft, Y, going from one end of the carriage to the other, and even a little beyond it; this shaft is carried by pieces y which are fixed to the arms Q, and in which it can turn. At its left end it carries two small bars y' and w', and at its right a single bar y', and a counterweight (not visible in this view); the ends of the two bars y' are joined by an iron wire somewhat stout and perfectly straight. When the carriage approaches the web, and before the iron wire can touch it, the little bar w presses against a pin, w', which rests upon it, and tends to raise it more and more. In what has preceded we have kept in view only the upper range of pincers and needles, but there is an inferior range quite similar, as the figure shows, at the lower ends of the arms Q. In conclusion, it should be stated, that the operative does not follow slidingly with the pantograph the trace of the design which is upon the tablet or the picture, but he must stop the point of the style upon the point of the pattern into which the needle should enter, then remove it, and put it down again upon the point by which the needle ought to re-enter in coming from the other side of the piece, and so on in succession. To facilitate this kind of reading off, the pattern upon the tablet is composed of right lines terminated by the points for the entrance and return of the needle, so that the operative (usually a child) has continually under her eyes the series of broken lines which must be followed by the pantograph; if she happens to quit this path an instant, without having left a mark of the point at which she had arrived, she is under the necessity of looking at the piece to see what has been already embroidered, and to find by this comparison the point at which she must resume her work, so as not to leave a blank, or to repeat the same stitch.

Explanation of figure.

A, lower cross bars, which unite the legs of the two ends of the frame.

a, the six feet of the front end of the frame.

a', the six feet of the posterior end of the frame.

a'', curved pieces which unite the cross bars A'' to the uprights.

B'', handle of the pantograph.

b b' b'', three of the angles of the pantograph.

c, point of the side b b'' on which the point is fixed.

c'', point of the pantograph.

D'', cross bar in form of a gutter, which unites the upper parts of the frame.

d, fixed point, round which the pantograph turns.

E, tablet upon which the pattern to be embroidered is put.

E', support of that tablet.

e, cord attached at one end to the side b c of the pantograph passing over a guide pulley, and carrying a weight at the other end.

t′, iron rod by which the table x is joined to its support x′.

r r, uprights of the cloth-carrying frame.

r′ r′, horizontal sides of the same frame.

e, four roll beams.

o″, the piece of cloth.

g″, the strings, which serve to stretch the cloth laterally.

EMERALD (*Emeraude*, Fr.; *Smaragd*, Germ.) is a precious stone of a beautiful green color; valued next to diamond, and in the same rank as oriental ruby and sapphire. It occurs in prisms with a regular hexagonal base; sp. grav. 2·7; scratches quartz with difficulty; is scratched by topaz; fusible at the blowpipe into a frothy bead; the precipitate afforded by ammonia, from its solution, is soluble, in a great measure, in carbonate of ammonia. Its analysis is given very variously by different chemists. It contains about 14 per cent. of glucina, which is its characteristic constituent; along with 68 of silica, 16 of alumina, a very little lime and iron. The beautiful emerald of Peru is found in a clay schist mixed with some calcareous matter. A stone of 4 grains weight is said to be worth from 4*l*. to 5*l*.; one of 8 grains, 10*l*.; one of 15 grains, being fine, is worth 60*l*.; one of 24 grains fetched, at the sale of M. de Drée's cabinet, 2400 francs, or nearly 100*l*.

The beryl is analogous in composition to the emerald, and is employed (when of the common opaque kind, found near Limoges) by chemists for procuring the earth glucina.

EMERY. This mineral was long regarded as an ore of iron; and was called by Haüy *fer oxidé quartzifère*. It is very abundant in the island of Naxos, at cape Emeri, whence it is imported in large quantities. It occurs also in the islands of Jersey and Guernsey, at Almaden, in Poland, Saxony, Sweden, Persia, &c. Its color varies from red brown to dark brown; its specific gravity is about 4·000; it is so hard as to scratch quartz and many precious stones. By Mr. Tenant's analysis it consists of alumina, 80; silica, 3; iron, 4. Another inferior kind yielded 32 of iron, and only 50 of alumina.

The alumina of emery is believed to be aggregated to the same degree of hardness as in corundum or adamantine spar; which is one of the hardest minerals known. Emery is extensively employed for grinding metals, glass, &c.; for which purpose it is reduced to powders of different degrees of fineness, by grinding and elutriation. When so treated, it is sold under the name of flour of emery, or washed emery.

EMPYREUMA, means the offensive smell produced by fire applied to organic matters, chiefly vegetable, in close vessels. Thus, empyreumatic vinegar is obtained by distilling wood at a red heat, and empyreumatic oil from many animal substances in the same way.

ENAMELS (*Emaux*, Fr.; *Schmelzglas*, Germ.) are varieties of glass, generally opaque and colored, always formed by the combination of different metallic oxydes, to which certain fixed fusible salts are added, such as the borates, fluates, and phosphates.

The simplest enamel, and the one which serves as a basis to most of the others, is obtained by calcining first of all a mixture of lead and tin, in proportions varying from 15 to 50 parts of tin for 100 of lead. The middle term appears to be the most suitable for the greater number of enamels; and this alloy has such an affinity for oxygen, that it may be calcined with the greatest ease in a flat cast-iron pot, and at a temperature not above a cherry red, provided the dose of tin is not too great. The oxyde is drawn off to the sides of the melted metal according as it is generated, new pieces of the alloy being thrown in from time to time, till enough of the powder be obtained. Great care ought to be taken that no metallic particles be left in the oxyde, and that the calcining heat be as low as is barely sufficient; for a strong fire frits the powder, and obstructs its subsequent comminution. The powder when cold is ground in a proper mill, levigated with water, and elutriated, as will be described under *Red lead*. In this state of fineness and purity, it is called calcine, or flux, and it is mixed with silicious sand and some alkaline matter or sea-salt. The most ordinary proportions are, 4 of sand, 1 of sea-salt, and 4 of *calcine*. Chaptal states that he has obtained a very fine product from 100 parts of calcine, made by calcining equal parts of lead and tin, 100 parts of ground flint, and 200 parts of pure subcarbonate of potash. In either case, the mixture is put into a crucible, or laid simply on a stratum of sand, quicklime spontaneously slaked, or wood-ashes, placed under a pottery or porcelain kiln. This mass undergoes a semi-vitrification; or even a complete fusion on its surface. It is this kind of frit which serves as a radical to almost every enamel; and by varying the proportions of the ingredient, more fusible, more opaque, or whiter enamels are obtained. The first of these qualities depends on the quantity of sand or flux, and the other two on that of the tin.

The sea-salt employed as a flux may be replaced either by salt of tartar, by pure potash, or by soda; but each of these fluxes gives peculiar qualities to the enamel.

Most authors who have written on the preparation of enamels, insist a great deal on

e necessity of selecting carefully the particular sand that should enter into the composi-
m of the frit, and they even affirm that the purest is not the most suitable. Clouet
ttes, in the 34th volume of the *Annales de Chimie*, that the sand ought to contain at
1st 1 part of talc for 3 of silicious matter, otherwise the enamel obtained is never very
assy, and that some wrinkled spots from imperfect fusion are seeen on its surface; and
t we find prescribed in some old treatises, to make use of ground flints, fritted by means
salt of tartar or some other flux. It would thence appear that the presence of talc is
no use towards the fusibility of the silica, and that its absence may be supplied by in-
masing the dose of the flux. In all cases, however, we ought to beware of metallic
ydes in the sand, particularly those of iron and manganese, which most frequently occur,
d always injure the whiteness of the frit.

The ancients carried the art of enamelling to a very high perfection, and we occasion-
y find beautiful specimens of their work, of which we know neither the composition,
r the manner of applying it. Then, as at present, each artist made a mystery of the
ians that succeeded best with *him*, and thus a multitude of curious processes have been
ried with their authors. Another cause contributes powerfully to this sort of declen-
m in the arts. Among the vast number of recipes which have been published for the
mation of enamels, there are several in which substances are mentioned that can no
iger be procured, whether owing to a change of denomination, or because the substan-
s cannot now be found in commerce, or because they are not of the same nature as of
L. Hence, in many cases, we find it impossible to obtain satisfactory results. What
: have now said renders it desirable that the operations should be resumed anew, or
on new bases, and availing ourselves of all the known chemical facts, we should employ
the production of enamels, raw materials of the purest kind.

The Venetians are still in possession of the best enamel processes, and they supply the
eneh and other nations with the best kinds of enamel, of every colored shade.

Enamels are distinguished into transparent and opaque; in the former all the elements
ve experienced an equal degree of liquefaction, and are thus run into crystal glass,
iilst in the others, some of their elements have resisted the action of heat more, so that
ir particles retain sufficient aggregation to prevent the transmission of light. This
ect is produced, particularly by the oxyde of tin, as we shall perceive in treating of
iite enamel.

The frits for enamels that are to be applied to metallic surfaces require greater fusibil-
, and should therefore contain more flux; and the sand used for these should be calcined
forehand with one fourth its weight of sea-salt; sometimes, indeed, metallic fluxes are
ded, as minium or litharge. For some metallic colors, the oxydes of lead are very in-
rious, and in this case recourse must be had to other fluxes. Clouet states that he had
rived advantage from the following mixtures, as bases for purples, blues, and some
ier delicate colors :—

Three parts of silicious sand, one of chalk, and three of calcined borax; or, three of
iss (of broken crystal goblets), one of calcined borax, one fourth of a part of nitre, and
e part of well washed diaphoretic antimony. These compositions afford a very white
amel, which accords perfectly well with blue.

It is obvious that the composition of this primary matter may be greatly varied; but
: should never lose sight of the essential quality of a good enamel; which is, to acquire,
a moderate heat, sufficient fluidity, to take a shining surface, without running too thin.
is not complete fusion which is wanted; but a pasty state, of such a degree as may
ve it, after cooling, the aspect of having suffered complete liquefaction.

Dead-white Enamel.—This requires greater nicety in the choice of its materials than
iy other enamel, as it must be free from every species of tint, and be perfectly white;
ice the frit employed in this case should be itself composed of perfectly pure ingre-
ents. But a frit should not be rejected hastily because it may be somewhat discolored,
ice this may depend on two causes; either on some metallic oxydes, or on fuliginous
irticles proceeding from vegetable or animal substances. Now the latter impurities may
: easily removed by means of a small quantity of peroxyde of manganese, which has
e property of readily parting with a portion of its oxygen, and of thus facilitating the
mbustion, that is to say, the destruction of the coloring carbonaceous matter. Manga-
ise indeed possesses a coloring power itself on glass, but only in its highest state of
tydizement, and when reduced to the lower state, as is done by incombustible matters,
io longer communicates color to the enamel combinations. Hence the proportion of
anganese should never exceed what is just; for the surplus would cause color. Some-
mes, indeed, it becomes necessary to give a little manganese color, in order to tain a
ore agreeable shade of white; as a little azure blue is added to linens, to b m or
vinteract the dulness of their yellow tint.

A white enamel may be conveniently prepared also with a *calcine* composed of two
trts of tin and one of lead calcined together; of this combined oxyde, one part is melted
ith two parts of fine crystal and a very little manganese, all previously ground together.

When the fusion is complete, the vitreous matter is to be poured into clear water, and the frit is then dried, and melted anew. The pouring into water and fusion are sometimes repeated four times, in order to secure a very uniform combination. The crucible must be carefully screened from smoke and flame. The smallest portions of oxyde of iron or copper admitted into this enamel will destroy its value.

Some practitioners recommend the use of washed diaphoretic antimony (antimoniate of potash, from metallic antimony and nitre deflagrated together) for white enamel; but this product cannot be added to any preparation of lead or other metallic oxydes; for it would tend rather to tarnish the color than to clear it up; and it can be used therefore only with ordinary glass, or with saline fluxes. For three parts of white glass (without lead) one part of washed diaphoretic antimony is to be taken; the substances are well ground together, and fused in the common way.

Blue enamel.—This fine color is almost always obtained from the oxyde of cobalt or some of its combinations, and it produces it with such intensity that only a very little can be used, lest the shade should pass into black. The cobalt blue is so rich and lively that it predominates in some measure over every other color, and masks many so that they can hardly be perceived; it is also most easily obtained. To bring it out, however, in all its beauty, the other colors must be removed as much as possible, and the cobalt itself should be tolerably pure. This metal is associated in the best known ores with a considerable number of foreign substances, as iron, arsenic, copper, nickel, and sulphur, and it is difficult to separate them completely; but for enamel blues, the oxyde of cobalt does not require to be perfectly free from all foreign metals; the iron, nickel, and copper, being most prejudicial, should be carefully eliminated. This object may be most easily attained by dissolving the ore in nitric acid, evaporating the solution to a sirupy consistence, to expel the excess of acid, and separate a portion of arsenic. It is now diluted with water, and solution of carbonate of soda is dropped slowly into it with brisk agitation, till the precipitate, which is at first of a whitish gray, begins to turn of a rose-red. Whenever this color appears, the whole must be thrown on a filter, and the liquid which passes through must be treated with more of the carbonate of soda, in order to obtain the arseniate of cobalt, which is nearly pure. Since arsenic acid and its derivatives are not capable of communicating color themselves, and as they moreover are volatile, they cannot impair the beauty of the blue, and hence this preparation affords it in great perfection.

Metallic fluxes are not the most suitable for this color; because they always communicate a tint of greater or less force, which never fails to injure the purity of the blue. Nitre is a useful addition, as it keeps the oxyde at the maximum of oxydation, in which state it produces the richest color.

Yellow Enamel.—There are many processes for making this color in enamel; but it is somewhat difficult to fix, and it is rarely obtained of a uniform and fine tint. It may be produced directly with some preparations of silver, as the phosphate or sulphate; but this method does not always succeed, for too strong a heat or powerful fluxes readily destroy it, and nitre is particularly prejudicial. This uncertainty of success with the salts of silver causes them to be seldom employed; and oxydes of lead and antimony are therefore preferred, which afford a fine yellow when combined with some oxydes that are refractory enough to prevent their complete vitrification. One part of white oxyde of antimony may be taken with from one to three parts of white lead, one of alum, and one of sal-ammoniac. Each of these substances is to be pulverized, and then all are to be exactly mixed, and exposed to a heat adequate to decompose the sal-ammoniac. This operation is judged to be finished when the yellow color is well brought out. There is produced here a combination quite analogous to that known under the name of Naples yellow.

Other shades of yellow may be procured either with the oxyde of lead alone, or by adding to it a little red oxyde of iron; the tints varying with the proportion of the latter.

Clouet says, in his memoir on enamels, that a fine yellow is obtained with pure oxyde of silver, and that it is merely necessary to spread a thin coat of it on the spot to be colored. The piece is then exposed to a moderate heat, and withdrawn as soon as this has reached the proper point. The thin film of metallic silver revived on the surface being removed, the place under it will be found tinged of a fine yellow, of hardly any thickness. As the pellicle of silver has to be removed which covers the color, it is requisite to avoid fixing this film with fluxes; and it ought therefore to be applied after the fusion of the rest. The yellows require in general little flux, and they answer better with one of a metallic nature.

Green Enamel.—It is known that a green color may be produced by a mixture of yellow and blue; but recourse is seldom had to this practice for enamels, as they can be obtained almost always directly with the oxyde of copper; or still better with the oxyde of chrome, which has the advantage of resisting a strong heat.

hemists describe two oxydes of copper, the protoxyde, of an orange red color, which
municates its color to enamels, but it is difficult to fix; the deutoxyde is blue in the
: of hydrate, but blackish-brown when dry, and it colors green all the vitreous com-
.tions into which it enters.   This oxyde requires, at most, one or two proportions of
, either saline or metallic, to enter into complete fusion; but a much smaller dose is
monly taken, and a little oxyde of iron is introduced.   To four pounds of frit, for in-
ce, two ounces of oxyde of copper and 48 grains of red oxyde of iron are used; and
ordinary measures are pursued for making very homogeneous enamel.
he green produced by the oxyde of chrome is much more solid; it is not affected by a
erful fire, but it is not always of a fine shade.   It generally inclines too much to the
l-leaf yellow, which depends on the degree of oxygenation of the chrome.
ed Enamel.—We have just stated that protoxyde of copper afforded a fine color
n it could be fixed, a result difficult to obtain on account of the fugitive nature of
oxyde; slight variations of temperature enabling it to absorb more oxygen.   The
er point of fusion must be seized, for taking it from the fire whenever the desired
r is brought out.   Indeed, when a high temperature has produced peroxydizement,
may be corrected by adding some combustible matter, as charcoal, tallow, tartar,
    The copper then returns to its minimum of oxydizement, and the red color which
vanished, reappears.   It is possible, in this way, and by pushing the heat a little,
ccomplish the complete reduction of a part of the oxyde; and the particles of metallic
er thereby disseminated in a reddish ground, give this enamel the aspect of the
e called *avanturine*.   The surest and easiest method of procuring protoxyde of
er is to boil a solution of equal parts of sugar, and sulphate or rather acetate of
er, in four parts of water.   The sugar takes possession of a portion of the oxygen
he cupreous oxyde, and reduces it to the protoxyde; when it may be precipitated in
form of a granular powder of a brilliant red.   After about two hours of moderate
lition, the liquid is set aside to settle, decanted off the precipitate, which is washed
dried.
his pure oxyde, properly employed by itself, furnishes a red which vies with the finest
nine, and by its means every tint may be obtained from red to orange, by adding a
iter or smaller quantity of peroxyde of iron.
he preparations of gold, and particularly the oxyde and purple of Cassius, are like-
e employed, with advantage, to color enamel red, and this composition resists a power-
fire tolerably well.   For some time back, solutions of gold, silver, and platinum have
n used with success instead of their oxydes; and, in this way, a more intimate mix-
e may be procured, and, consequently, more homogeneous tints.
Black Enamel.—Black enamels are made with peroxyde of manganese or protoxyde of
i; to which more depth of color is given with a little cobalt.   Clay alone, melted
h about a third of its weight of protoxyde of iron, gives, according to Clouet, a fine
:k enamel.
Violet Enamel.—The peroxyde of manganese in small quantity by itself furnishes,
h saline or alkaline fluxes, an enamel of a very fine violet hue; and variations of
de are easily had by modifying the proportions of the elements of the colored
.   The great point is to maintain the manganese in a state of peroxydation, and con-
nently to beware of placing the enamel in contact with any substance attractive of
gen.
ach are the principal colored enamels hitherto obtained by means of metallic oxydes;
since the number of these oxydes is increasing every day, it is to be wished that new
ls be made with such as have not yet been employed.   From such researches some
resting results would unquestionably be derived.
Of painting on Enamel.—Enamelling is only done on gold and copper; for silver swells
and causes blisters and holes in the coat of enamel.   All enamel paintings are, in
, done on copper or gold.
The goldsmith prepares the plate that is to be painted upon.   The gold should be 22
ats fine: if purer, it would not be sufficiently stiff; if coarser, it would be subject to
1; and its alloy should be half white and half red, that is, half silver and half copper;
ereby the enamel with which it is covered will be less disposed to turn green, than if
alloy were entirely copper.
The workman must reserve for the edge of the plate a small fillet, which he calls the
ler.   This ledge serves to retain the enamel, and hinders it from falling off when
lied and pressed on with a spatula.   When the plate is not to be counter-enamelled, it
uld be charged with less enamel, as, when exposed to heat, the enamel draws up the
l to itself, and makes the piece convex.   When the enamel is not to cover the whole
te, it becomes necessary to prepare a lodgment for it.   With this view, all the out-
e of the figure are traced on the plate with a black-lead pencil, after which recourse
ad to the graver.
The whole space enclosed by the outlines must be hollowed out in *bas-relief*, of a

depth equal to the height of the fillet, had the plate been entirely enamelled. This sinking of the surface must be done with a flat graver as equally as possible; for if there be an eminence, the enamel would be weaker at that point, and the green would appear. Some artists hatch the bottom of the hollow with close lines, which cross each other in all directions; and others make lines or scratches with the end of a file broken off square. The hatchings or scratches lay hold of the enamel, which might otherwise separate from the plate. After this operation, the plate is cleansed by boiling it in an alkaline ley, and it is washed first with a little weak vinegar, and then with clear water.

The plate thus prepared is to be covered with a coat of white enamel, which is done by bruising a piece of enamel in an agate or porcelain mortar to a coarse powder like sand, washing it well with water, and applying it in the hollow part in its moist state. The plate may meanwhile be held in an ordinary forceps. The enamel powder is spread with a spatula. For condensing the enamel powder, the edges of the plate are struck with this spatula.
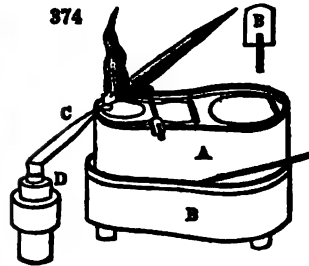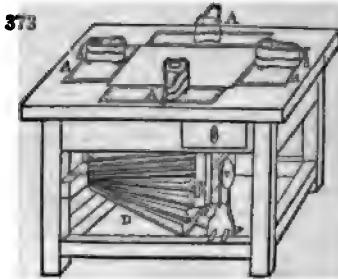
Whenever the piece is dry, it is placed on a slip of sheet iron perforated with several small holes, see *fig.* 375, which is laid on hot cinders; and it is left there until it comes to steam. It must be kept hot till it goes to the fire; for were it allowed to cool it would become necessary to heat it again very gradually at the mouth of the furnace of fusion, to prevent the enamel from decrepitating and flying off.
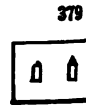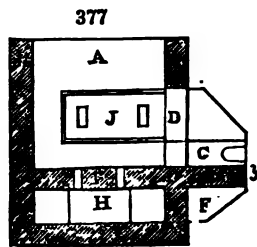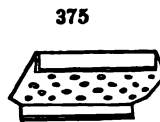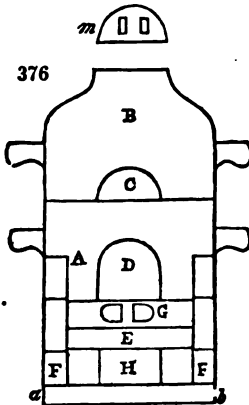
Before describing the manner of exposing the piece to the fire, we must explain the construction of the furnace. It is square, and is shown in front elevation in *fig.* 376. It consists of two pieces, the lower part A, or the body of the furnace, and the upper part B, or the capital, which is laid on the lower part as is shown in *fig.* 377, where these two parts are separately represented. The furnace is made of good fire-clay, moderately baked, and resembles very closely the assay or cupellation furnace. Its inside dimensions are 9 inches in width; 13 inches in height in the body, and 9 in the capital. Its general thickness is 2 inches.

The capital has an aperture or door c, *fig.* 376, which is closed by a fire-brick stopper m, when the fire is to be made active. By this door fuel is supplied.

of the furnace has likewise a door D, which reaches down to the projecting
1 the bib (*mentonnière*), whose prominence is seen at E, *fig.* 376. This
)rted and secured by the two brackets F, F; the whole being earthenware.
'the door D is abridged by a peculiar fire-brick G, which not only covers the
tion of the shelf E, but enters within the opening of the door D, filling its
advancing into the same plane with the inner surface of the furnace. This
d the hearth; its purpose will appear presently; it may be taken out and
easure, by laying hold of the handle in its front.
shelf E, a square hole, H, is seen, which serves for admitting air, and for
e ashes. Similar holes are left upon each side of the furnace, as is shown
plan of the base, *fig.* 377, at H H H.
with the shelf, in the interior of the furnace, a thin fire-tile I rests, perfo-
merous small holes. This is the grate represented in a ground view in *fig.*
78, 379, 380, represent, under different aspects, the muffle. *Fig.* 377 shows
of its further end; *fig.* 379 its sides; and *fig.* 380 its front part. At J, *fig.*
le is seen in its place in the furnace, resting on two bars of iron, or, still
ges of fire-clay, supported on brackets attached to the lateral sides of the
e muffle is made of earthenware, and as thin as possible. The fuel consists
wood, or oaken branches, about an inch in diameter, cut to the length of 9
ler to be laid in horizontal strata within the furnace, one row only being
the muffle. When the muffle has attained to a white-red heat, the sheet
iring its enamel plate, is to be introduced with a pair of pincers into the
nuffle, and gradually advanced towards its further end. The mouth of the
ie then closed with two pieces of charcoal only, between which the artist
progress of the operation. Whenever the enamel begins to flow, the tray
:d round on its base to ensure equality of temperature; and as soon as the
· is melted, the tray must be withdrawn with its plate, but slowly, lest the
er be cracked by sudden refrigeration.
:l plate, when cold, is to be washed in very dilute nitric acid, and after-
water, and a second coat of granular enamel paste is to be applied, with
precautions. This, being passed through the fire, is to be treated in the
.hird time, when the process will be found complete. Should any chinks
ie enamel coat, they must be widened with a graver, and the space
rith ground enamel, is to be repaired in the muffle. The plate, covered
rhite enamel, requires always to be polished and smoothed with sandstone
irticularly if the article have a plane surface; and it is then finally glazed

1g operation now follows. The artist prepares his enamel colors by pound-
n agate mortar, with a pestle of agate, and grinding them on an agate slab,
vender, rendered viscid by exposure to the sun in a shallow vessel, loosely
gauze or glass. The grinding of two drachms of enamel pigment into an
iwder, will occupy a laborer a whole day. The painter should have along-
stove in which a moderate fire is kept up, for drying his work whenever
e finished. It is then passed through the muffle.
; *at the Lamp.*—The art of the lamp enameller is one of the most agreeable
that we know. There is hardly a subject in enamel which may not be
:he lamp-flame in very little time, and more or less perfectly, according to
of the artist, and his acquaintance with the principles of modelling.
at the lamp, tubes and rods of glass and enamel must be provided, of all
)rs.
lling table is represented in *fig.* 373, round which several workmen, with
nay be placed, while the large double bellows D below is set a-blowing by a
l with the foot. The flame of the lamp, when thus impelled by a powerful
iuires surprising intensity. The bent nozzles or tubes, A A A A, are made
are drawn to points modified to the purpose of the enameller.
iows, in perspective, the lamp A of the enameller standing in its cistern B;
c is seen projecting its flame obliquely upwards. The blowpipe is adjust-
stic cork D, which fills up exactly the hole of the table into which it enters.
ie person is to work at a table provided with several lamps, he sits down at
with the pedal of the bellows; he takes out the other blowpipes, and plugs
he table with solid corks.
s made of copper or tin-plate, the wick of cotton threads, and either tallow
: used. Between the lamp and the workman a small board or sheet of
called the screen, is interposed to protect his eyes from the glare of light.
fastened to the table by a wooden stem, and it throws its shadow on his

The enamelling workshop ought to admit little or no daylight, otherwise the artist, not perceiving his flame distinctly, would be apt to commit mistakes.

It is impossible to describe all the manipulations of this ingenious art, over which taste and dexterity so entirely preside. But we may give an example. Suppose the enameller wishes to make a swan. He takes a tube of white enamel, seals one of its ends hermetically at his lamp, and while the matter is sufficiently hot, he blows in it a minikin flask, resembling the body of the bird; he draws out, and gracefully bends the neck; he shapes the head, the beak, and the tail; then, with slender enamel rods of a proper color, he makes the eyes; he next opens up the beak with pointed scissors; he forms the wings and the legs; finally attaching the toes, the bird stands complete.

The enameller also makes artificial eyes for human beings, imitating so perfectly the colors of the sound eye of any individual, as to render it difficult to discover that he has a blind and a seeing one.

It is difficult to make large articles at the blowpipe; those which surpass 5 or 6 inches become nearly unmanageable by the most expert workman.

EPSOM SALTS. Sulphate of Magnesia.

EQUIVALENTS, CHEMICAL. (*Stöchiometrie*, Germ.) This expression was first employed by Dr. Wollaston, to denote the primary proportions in which the various chemical bodies reciprocally combine; the numbers representing these proportions being referred to one standard substance of general interest, such as oxygen or hydrogen reckoned unity, or 1,000. Dr. Dalton, who is the true author of the grand discovery of definite and multiple chemical ratios, calls these equivalent numbers *atomic weight*, when reduced to their lowest terms, either hydrogen or oxygen being the radix of the scale. Though it belongs to a chemical work to discuss the principles and develop the applications of the Atomic Theory, I shall be careful, upon all proper occasions, to point out the vast advantages which the chemical manufacturer may derive from it, and to show how much he may economize and improve his actual processes by its means. See ELEMENT.

ESSENCES are either ethereous oils, in which all the fragrance of vegetable products reside; or the same combined and diluted with alcohol. See OILS, ETHEREOUS.

ESSENCE D'ORIENT, the name of a pearly looking matter procured from the blay or bleak, a fish of the genus *cyprinus*. This substance, which is found principally at the base of the scales, is used in the manufacture of artificial pearls. A large quantity of the scales being scraped into water in a tub, are there rubbed between the hands to separate the shining stuff, which subsides on repose. The first water being decanted, more is added with agitation till the essence is thoroughly washed from all impurities; when the whole is thrown upon a sieve; the substance passes through, but the scales are retained. The water being decanted off, the essence is procured in a viscid state, of a bluish white color, and a pearly aspect. The intestines of the same fish are also covered with this beautiful glistening matter. Several other fish yield it, but in smaller proportion. When well prepared, it presents exactly the appearance and reflections of the real pearls, or the finest mother of pearl; properties which are probably owing to the interposition of some portions of this same substance, between the laminæ of these shelly concretions. Its chemical nature has not been investigated; it putrefies readily when kept moist, an accident which may, however, be counteracted by water of ammonia. See PEARLS.

ETCHING *Varnish*. (*Aetzgrund-Deckfirniss*, Germ.) Though the practice of this elegant art does not come within the scope of our Dictionary, the preparation of the varnishes, and of the biting menstrua which it employs, legitimately does.

The varnish of Mr. Lawrence, an English artist resident in Paris, is made as follows: Take of virgin wax and asphaltum, each two ounces, of black pitch and burgundy-pitch each half an ounce. Melt the wax and pitch in a new earthenware glazed pot, and add to them, by degrees, the asphaltum, finely powdered. Let the whole boil till such time as that, taking a drop upon a plate, it will break when it is cold, on bending it double two or three times betwixt the fingers. The varnish, being then enough boiled, must be taken off the fire, and after it cools a little, must be poured into warm water that it may work the more easily with the hands, so as to be formed into balls, which must be kneaded, and put into a piece of taffety for use.

Care must be taken, first, that the fire be not too violent, for fear of burning the ingredients, a slight simmering being sufficient; secondly, that whilst the asphaltum is putting in, and even after it is mixed with the ingredients, they should be stirred continually with the spatula; and thirdly, that the water into which this composition is thrown should be nearly of the same degree of warmth with it, in order to prevent a kind of cracking that happens when the water is too cold.

The varnish ought always to be made harder in summer than in winter, and it will become so if it be suffered to boil longer, or if a greater proportion of the asphaltum or

brown rosin be used. The experiment above mentioned, of the drop suffered to cool, will determine the degree of hardness or softness that may be suitable to the season when it is used.

Preparation of the hard varnish used by Callot, commonly called the Florence Varnish :—Take four ounces of fat oil very clear, and made of good linseed oil, like that used by painters; heat it in a clean pot of glazed earthenware, and afterwards put to it four ounces of mastick well powdered, and stir the mixture briskly till the whole be well melted, then pass the mass through a piece of fine linen into a glass bottle with a long neck, that can be stopped very securely; and keep it for the use that will be explained below.

Method of applying the soft varnish to the plate, and of blackening it :—The plate being well polished and burnished, as also cleansed from all greasiness by chalk or Spanish white, fix a hand-vice on the edge of the plate where no work is intended to be, to serve as a handle for managing it when warm; then put it upon a chafing dish, in which there is a moderate fire, and cover the whole plate equally with a thin coat of the varnish; and whilst the plate is warm, and the varnish upon it in a fluid state, beat every part of the varnish gently with a small ball or dauber made of cotton tied up in taffety, which operation smooths and distributes the varnish equally over the plate.

When the plate is thus uniformly and thinly covered with the varnish, it must be blackened by a piece of flambeau, or of a large candle which affords a copious smoke; sometimes two or even four such candles are used together for the sake of despatch, that the varnish may not grow cold, which if it does during the operation, the plate must be heated again, that it may be in a melted state when that operation is performed; but great care must be taken not to burn it, which, when it happens, may be easily perceived by the varnish appearing burnt, and losing its gloss.

The menstruum used and recommended by Turrell, an eminent London artist, for etching upon steel, was prepared as follows :—

> Take Pyroligneous acid 4 parts by measure,
> Alcohol   1 part, mix, and add
> Nitric acid   1 part.

This mixed liquor is to be applied from 1½ to 15 minutes, according to the depth desired. The nitric acid was employed of the strength of 1·28—the double aquafortis of the shops.

The *eau forte* or menstruum for copper, used by Callot, as also by Piranesi, with a slight modification, is prepared with 8 parts of strong French vinegar,

> 4 parts of verdigris,
> 4 ditto sea salt,
> 4 ditto sal ammoniac,
> 1 ditto alum,
> 16 ditto water.

The solid substances are to be well ground, dissolved in the vinegar, and diluted with the water; the mixture is now to be boiled for a moment, and then set aside to cool. This menstruum is applied to the washed, dried, and varnished plate, after it has suffered the ordinary action of aquafortis, in order to deepen and finish the delicate touches. It is at present called the *eau forte à passer*.

ETHER is the name of a class of very light, volatile, inflammable, and fragrant spirituous liquids, obtained by distilling, in a glass retort, a mixture of alcohol with almost any strong acid. Every acid modifies the result, in a certain degree, whence several varieties of ether are produced. The only one of commercial importance is sulphuric ether, which was first made known under the name of *sweet oil of vitriol*, in 1540, by the receipt of Walterus Cordus. Froberus, 190 years after that date, directed the attention of chemists afresh to this substance, under the new denomination of *ether*.

There are two methods of preparing it; by the first, the whole quantity of acid and alcohol are mixed at once, and directly subjected to distillation; by the second, the alcohol is admitted, in a slender streamlet, into a body of acid previously mixed with a little alcohol, and heated to 220° Fahr.

1. Mix equal weights of alcohol at spec. grav. 0·830, and sulphuric acid at 1·842, by introducing the former into a large tubulated retort, giving it a whirling motion, so that the alcohol may revolve round a central conical cavity. Into this species of whirlpool the acid is to be slowly poured. The mixture, which beccmes warm, is to be forthwith distilled by attaching a spacious receiver to the retort, and applying the heat of a sand-bath. The formation of ether takes place only at a certain temperature. If the contents of the retort be allowed to cool, and be then slowly heated in a water-bath, alcohol alone will come over for some time without ether, till the mixture acquires the

proper degree of heat. The first receiver should be a globe, with a tube proceeding from its bottom, into a second receiver, of a cylindric shape, surrounded with ice-cold water. The joints must be well secured by lutes, after the expanded air has been allowed to escape. The liquid in the retort should be kept in a steady state of ebullition. The ether, as long as it is produced, condenses in the balloon and neck of the receiver in striæ; when these disappear the process is completed. The retort must now be removed from the sand; otherwise it would become filled with white fumes containing sulphurous acid, and denser striæ would flow over, which would contaminate the light product with a liquid called sweet oil of wine.

The theory of etherification demonstrates that when strong sulphuric acid is mixed with alcohol, there is formed, on the one hand, a more aqueous sulphuric acid, and, on the other, sulphovinic acid. When this mixture is made to boil, the sulphovinic acid is decomposed, its dihydrate of carbon combines with the alcohol, and constitutes ether; while the proportion of sulphovinic acid progressively diminishes. Mr. Hennell, of the Apothecaries' Hall, first explained these phenomena, and he was confirmed in his views by the interesting researches of Serullas. The acid left in the retort is usually of a black color, and may be employed to convert into ether half as much alcohol again; an experiment which may be repeated several times in succession.

The most profitable way of manufacturing ether has been pointed out by Boullay. It consists in letting the alcohol drop in a slender stream into the acid, previously heated to the etherifying temperature. If the acid in this case were concentrated to 1·846, the reaction would be too violent, and the ether would be transformed into bicarbureted hydrogen (dihydrate of carbon). It is therefore necessary to dilute the acid down to the density of 1·780; but this dilution may be preferably effected with alcohol, instead of water, by mixing three parts of the strongest acid with 2 of alcohol, specific gravity 0·830, and distilling off a portion of the ether thereby generated; after which the stream of alcohol is to be introduced into the tubulure of the retort through a small glass tube plunged into the mixture; this tube being the prolongation of a metallic syphon, whose shorter leg dips into a bottle filled with the alcohol. The longer leg is furnished with a stop-cock, for regulating at pleasure the alcoholic streamlet. The distilled vapors should be transmitted through a worm of pure tin, surrounded by cold water, and the condensed fluid received in a glass bottle. The quantity of alcohol which can be thus converted into ether by a given weight of sulphuric acid, has not hitherto been accurately determined; but it is at least double. In operating in this way, neither sulphurous acid nor sweet oil of wine is generated, while the residuary liquid in the retort continues limpid and of a merely brownish yellow color. No sulphovinic acid is formed, and according to the experiments of Geiger, the proportion of ether approaches to what theory shows to be the maximum amount. In fact, 57 parts of alcohol of 0·83 sp. grav. being equivalent to 46·8 parts of anhydrous alcohol, yield, according to Geiger, 33½ parts of ether; and by calculation they should yield 37¼.

The ether of the first distillation is never pure, but always contains a certain quantity of alcohol. The density of that product is usually 0·78, and if prepared by the first of the above methods, contains, besides alcohol, pretty frequently sulphurous acid, and sweet oil of wine; impurities from which it must be freed. Being agitated with its bulk of milk of lime, both the acid and the alcohol are removed at the same time; and if it be then decanted and agitated, first with its bulk of water, next decanted into a retort containing chloride of calcium in coarse powder, and distilled, one third of perfectly pure ether may be drawn over. Gay Lussac recommends to agitate the ether, first with twice its volume of water, to mix it, and leave it in contact with powdered unslaked lime for 12 or 14 hours, and then to distil off one third of pure ether. The remaining two thirds consist of ether containing a little alcohol. If in preparing ether by Boullay's method, the alcohol be too rapidly introduced, much of this liquid will come over unchanged. If in this state the ether be shaken with water, a notable quantity of it will be absorbed, because weak alcohol dissolves it very copiously. The above product should therefore be re-distilled, and the first half that comes over may be considered as ether, and treated with water and lime. The other half must be exposed afresh to the action of sulphuric acid.

Pure ether possesses the following properties. It is limpid, of spec. grav. 0·713, or 0·715 at 60°; has a peculiar penetrating strong smell; a taste at first acrid, burning, sweetish, and finally cooling. It has neither an acid nor alkaline reaction; is a non-conductor of electricity, and refracts light strongly. It is very volatile, boiling at 96° or 97° F., and produces by its evaporation a great degree of cold. At the temperature of 62·4, the vapor of ether balances a column of mercury 15 inches high, or half the weight of the atmosphere. When ether is cooled to —24° F. it begins to crystallize in brilliant white plates, and at —47° it becomes a white crystalline solid. When vapor of ether is made to traverse a red hot porcelain tube, it deposites within it one half per cent. of charcoal, and there are condensed in the receiver one and two thirds

per cent. of a brown oil, partly in crystalline scales, and partly viscid. The crystalline portion is soluble in alcohol, but the viscid only in ether. The remainder of the decomposed ether consists of bi-carbureted hydrogen gas, tetrahydric carburet, carbonic oxyde gas, and one per cent. at most of gaseous carbonic acid.

Ether takes fire readily, even at some distance from a flame, and it should not therefore be poured from one vessel to another in the neighborhood of a lighted candle. It may be likewise set on fire by the electric spark. It burns all away with a bright fuliginous flame. When the vapor of ether is mixed with 10 times its volume of oxygen, it burns with a violent explosion, absorbs 6 times its bulk of oxygen, and produces 4 times its volume of carbonic acid gas.

Ether alters gradually with contact of air; absorbing oxygen, and progressively changing into acetic acid and water. This conversion takes place very rapidly when the ether is boiled in an open vessel, while the acid enters into a new combination forming acetic ether. Ether should be preserved in bottles perfectly full and well corked, and kept in a cool place, otherwise it becomes sour, and is destroyed. In contains in this state 15 per cent. of its bulk of azote, but no oxygen gas, as this has combined with its elements. Ether is composed of oxygen 21·24; hydrogen 13·85; carbon 65·05. This composition may be represented by 1 prime equivalent of water, and 4 primes of bi-carburetted hydrogen gas; in other words, ether contains for 1 prime of water, once as much olefiant gas as alcohol, and its prime equivalent is therefore 468·15 to oxygen 100. By my analysis, as published in the Phil. Trans. for 1822, ether is composed of oxygen 27·10; hydrogen 13·3; and carbon 59·6 in 100 parts. The density of my ether was 0·700. One volume of vapor of ether consists of one volume of aqueous vapor and two volumes of olefiant gas (bi-carbureted hydrogen), while alcohol consists of two volumes of each.

· ETHER, ACETIC, is used to flavor silent corn spirits in making imitation brandy. It may be prepared by mixing 20 parts of acetate of lead, 10 parts of alcohol, and 11½ of concentrated sulphuric acid; or 16 of the anhydrous acetate, 5 of the acid, and 4½ of absolute alcohol; distilling the mixture in a glass retort into a very cold receiver, agitating along with weak potash ley the liquor which comes over, decanting the supernatant ether, and rectifying it by re-distillation over magnesia and ground charcoal.

Acetic ether is a colorless liquid of a fragrant smell and pungent taste, of spec. grav. 0·866 at 45° F., boiling at 166° F., burning with a yellowish flame, and disengaging fumes of acetic acid. It is soluble in 8 parts of water.

Acetic ether may be economically made with 3 parts of acetate of potash, 3 of very strong alcohol, and 2 of the strongest sulphuric acid, distilled together. The first product must be re-distilled along with one fifth of its weight of sulphuric acid; as much ether will be obtained as there was alcohol employed.

ETHIOPS is the absurd name given by the alchemists to certain black metallic preparations. Martial ethiops was the black oxyde of iron; mineral ethiops, the black sulphuret of mercury; and ethiops *per se*, the black oxyde of mercury.

EVAPORATION (Eng. and Fr.; *Abdampfen; Abdunsten*, Germ.) is the process by which any substance is converted into, and carried off in, vapor. Though ice, camphor, and many other solids evaporate readily in dry air, I shall consider, at present, merely the vaporization of water by heat artificially applied.

The vapor of water is an elastic fluid, whose tension and density depend upon the temperature of the water with which it is in contact. Thus the vapor rising from water heated to 165° F. possesses an elastic force capable of supporting a column of mercury 10·8 high; and its density is such that 80 cubic feet of such vapor contain one pound weight of water; whereas 32¼ cubic feet of steam of the density corresponding to a temperature of 212° and a pressure of 30 inches of mercury, weigh one pound. When the temperature of the water is given, the elasticity and specific gravity of the vapor emitted by it may be found.

Since the vapor rises from the water only in virtue of the elasticity due to its gaseous nature, it is obvious that no more can be produced, unless what is already incumbent upon the liquid have its tension abated, or be withdrawn by some means. Suppose the temperature of the water to be midway between freezing and boiling, viz., 122° Fahr., as also that of the air in contact with it, to be the same but replete with moisture, so that its interstitial spaces are filled with vapor of corresponding elasticity and specific gravity with that given off by the water, it is certain that no fresh formation of vapor can take place in these circumstances. But the moment a portion of vapor is allowed to escape, or is drawn off by condensation to another vessel, an equivalent portion of vapor will be immediately exhaled from the water.

The pressure of the air and of other vapors upon the surface of water in an open vessel, does not prevent evaporation of the liquid; it merely retards its progress. Experience shows that the space filled with an elastic fluid, as air or other gaseous body, is capable of receiving as much aqueous vapor as if it were vacuous, only the repletion of that

space with the vapor proceeds more slowly in the former predicament than in the latter, but in both cases it arrives eventually at the same pitch. Dr. Dalton has very ingeniously proved, that the particles of aeriform bodies present no permanent obstacle to the introduction of a gaseous atmosphere of another kind among them, but merely obstruct its diffusion momentarily, as if by a species of friction. Hence, exhalation at atmospheric temperatures is promoted by the mechanical diffusion of the vapors through the air with ventilating fans or chimney draughts; though under brisk ebullition, the force of the steam readily overcomes that mechanical obstruction.

The quantities of water evaporated under different temperatures in like times, are proportional to the elasticities of the steam corresponding to these temperatures. A vessel of boiling water exposing a square foot of surface to the fire, evaporates 725 grains in the minute; the elasticity of the vapor is equivalent to 30 inches of mercury. To find the quantity that would be evaporated from the same surface per minute at a heat of 88° F. At this temperature the steam incumbent upon water is capable of supporting 1·28 inch of mercury; whence the rule of proportion is 30 : 1·28 : : 725 : 30·93; showing that about 31 grains of water would be evaporated in the minute. If the air contains already some aqueous vapor, as it commonly does, then the quantity of evaporation will be proportional to the difference between the elastic force of that vapor, and what rises from the water.

Suppose the air to be in the hygrometric state denoted by 0·38 of an inch of mercury, then the above formula will become: 30 : 1·28 — 0·38 : : 725 : 21·41; showing that not more than 21½ grains would be evaporated per minute under these circumstances.

The elastic tension of the atmospheric vapor is readily ascertained by the old experiment of Le Roi, which consists in filling a glass cylinder (a narrow tumbler for example) with cool spring water, and noting its temperature at the instant it becomes so warm that dew ceases to be deposited upon it. This temperature is that which corresponds to the elastic tension of the atmospheric vapor. See VAPOR, Table of.

Whenever the elasticity of the vapor, corresponding to the temperature of the water, is greater than the atmospheric pressure, the evaporation will take place not only from its surface, but from every point in its interior; the liquid particles throughout the mass assuming the gaseous form, as rapidly as they are actuated by the caloric, which subverts the hydrostatic equilibrium among them, to constitute the phenomena of ebullition. This turbulent vaporization takes place at any temperature, even down to the freezing point, provided the pneumatic pressure be removed from the liquid by the air pump, or any other means. Ebullition always accelerates evaporation, as it serves to carry off the aqueous particles not simply from the surface, but from the whole body of the water.

The vapors exhaled from a liquid at any temperature, contain more heat than the fluid from which they spring; and they cease to form whenever the supply of heat into the liquid is stopped. Any volume of water requires for its conversion into vapor *five and a half times* as much heat as is sufficient to heat it from the freezing to the boiling temperature. The heat, in the former case, seems to be absorbed, being inappreciable by the thermometer; for steam is no hotter than the boiling water from which it rises. It has been therefore called *latent heat ;* in contradistinction to that perceived by the touch and measured by the thermometer, which is called *sensible heat.* The quantity of heat absorbed by one volume of water in its conversion into steam, is about 1000° Fahr.; it would be adequate to heat 1000 volumes of water, one degree of the same scale; or to raise one volume of boiling water, confined in a non-conducting vessel, to 1180°. Were the vessel charged with water so heated, opened, it would be instantaneously emptied by vaporization, since the whole caloric equivalent to its constitution as steam, is present. When, upon the other hand, steam is condensed by contact with cold substances, so much heat is set free as is capable of heating five and a half times its weight of water, from 32° to 212° F. If the supply of heat to a copper be uniform, five hours and a half will be required to drive off its water in steam, provided one hour was taken in heating the water, from the freezing to the boiling pitch, under the atmospherical pressure.

Equal weights of vapor of any temperature contain equal quantities of heat; for example, the vapor exhaled from one pound of water, at 77° F., absorbs during its formation, and will give out in its condensation, as much heat as the steam produced by one pound of water, at 212° F. The first portion of vapor with a tension =30 inches, occupies a space of 27·31 cubic feet; the second, with a tension of 0·92 inch, occupies a space of 890 cubic feet.* Suppose that these 890 volumes were to be compressed into 27·31 in a cylinder capable of confining the heat, the temperature of the vapor would rise from 77° to 212°, in virtue of the condensation, as air becomes so hot by com-

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* One pound avoirdupois of water contains 27·72 cubic inches ; one cubic inch of water forms 1696 cubic inches of steam at 212° F. : therefore one pound of water will form 27·31 cubic feet of such steam: and 0·92 : 30 : : 27·31 : 890 cubic feet.

:ssion in a syringe, as to ignite *amadou*. The latent heat of steam at 212° F. is 80°—180=1000; that of vapor, at 77°, is 1180—45=1135°; so that, in fact, the ver the temperature at which the vapor is exhaled, the greater is its latent heat, as seph Black and James Watt long ago proved by experiments upon distillation and the :am engine.

From the preceding researches it follows, that evaporation may be effected upon two ferent plans :—

1. Under the ordinary pressure of the atmosphere; and that either,

A, by external application of heat to boilers, with a, an open fire; b, steam; c, hot uid-*media*.

B, by evaporation with air; a, at the ordinary temperature of the atmosphere; b, by rrents of warm air.

2. Under progressively lower degrees of pressure than the atmospheric, down to aporation in as perfect a vacuum as can be made.

It is generally affirmed, that a thick metallic boiler obstructs the passage of the heat rough it so much more than a thin one, as to make a considerable difference in their lative powers of evaporating liquids. Many years ago, I made a series of experiments on this subject. Two cylindrical copper pans, of equal dimensions, were provided; it the metal of the one was twelve times thicker than that of the other. Each being arged with an equal volume of water, and placed either upon the same hot plate of n, or immersed, to a certain depth, in a hot solution of muriate of lime, I found that e ebullition was greatly more vigorous in the thick than in the thin vessel, which I cribed to the conducting substance up the sides, above the contact of the source of at, being 12 times greater in the former case than in the latter.

If the bottom of a pan, and the portions of the sides, immersed in a hot fluid medium, lution of caustic potash or muriate of lime, for example, be corrugated, so as to contain double expanse of metallic surface, that pan will evaporate exactly double the quantity water, in a given time, which a like pan, with smooth bottom and sides, will do imersed equally deep in the same bath. If the corrugations contain three times the antity of metallic surface, the evaporation will be threefold in the above circum-nces. But if the pan, with the same corrugated bottom and sides, be set over a fire, in an oblong flue, so that the current of flame may sweep along the corrugations, it ill evaporate no more water from its interior than a smooth pan of like shape and mensions placed alongside in the same flue, or over the same fire. This curious fact have verified upon models constructed with many modifications. Among others, I used a cylindrical pan, 10 inches diameter, and 6 inches deep, to be made of tin-ate, with a vertical plate soldered across its diameter; dividing it into two equal mi-cylindrical compartments. One of these was smooth at the bottom, the other rrugated; the former afforded as rapid an evaporation over the naked fire as the tter, but it was far outstripped by its neighbor when plunged into the heated liquid edium.

If a shallow pan of extensive surface be heated by a subjacent fire, by a liquid medium a series of steam pipes upon its bottom; it will give off less vapor in the same time hen it is left open, than when partially covered. In the former case, the cool in-mbent air precipitates by condensation a portion of the steam, and also opposes nsiderable mechanical resistance to the diffusion of the vaporous particles. In the tter case, as the steam issues with concentrated force and velocity from the contracted ifice, the air must offer less proportional resistance, upon the known hydrostatic inciple of the pressure being as the areas of the respective bases, in communicating ssels.

In evaporating by surfaces heated with ordinary steam, it must be borne in mind at a surface of 10 square feet will evaporate fully one pound of water per minute, or !5× 10 = 7250 gr., the same as over a naked fire; consequently the condensing sur-ce must be equally extensive. Suppose that the vessel is to receive of water 2500 s., which corresponds to a boiler 5 feet long, 4 broad, and 2 deep, being 40 cubic et by measure, and let there be laid over the bottom of this vessel 8 connected tubes ch 5 inches in diameter and 5 feet long, possessing therefore a surface of 5 feet square. charged with steam, they will cause the evaporation of half a pound of water per nute. The boiler to supply the steam for this purpose must expose a surface of 5 uare feet to the fire. It has been proved experimentally that 10 square feet surface 'thin copper can condense 3 lbs. of steam per minute, with a difference of temperature '90 degrees Fahr. In the above example, 10 square feet evaporate 1 lb. of water r minute; the temperature of the evaporating fluid being 212° F., consequently : 1 : : 90 : $\frac{90}{3}$. During this evaporation the difference of the temperature is there-re = 30°. Consequently the heat of the steam placed in connexion with the inte-or of the boiler, to produce the calculated evaporation, should be, 212 + 30 = 242°, rresponding to an elastic force of 53·6 inches of mercury. Were the temperature of

the steam only 224, the same boiler in the same time would produce a diminished quantity of steam, in the proportion of 12 to 30; or to produce the same quantity the boiler or tubular surface should be enlarged in the proportion of 30 to 12. In general, however, steam boilers employed for this mode of evaporation are of such capacity as to give an unfailing supply of steam.

I shall now illustrate by some peculiar forms of apparatus, different systems of evaporation. *Fig.* 381 explains the principles of evaporating in vacuo. A B represents
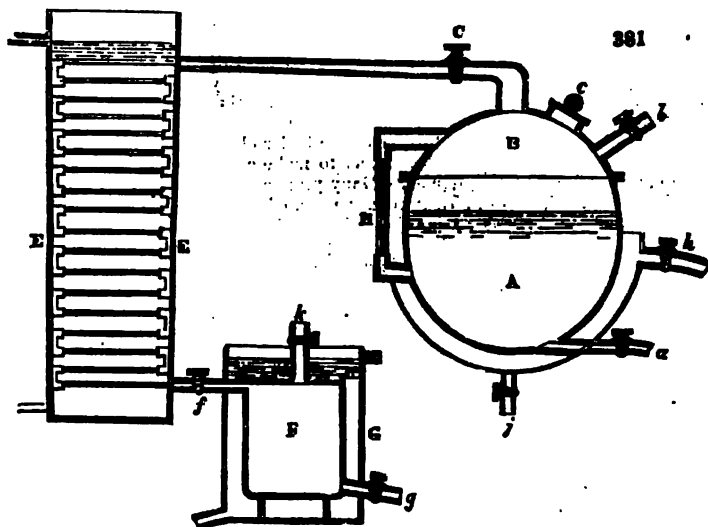
a pan or kettle charged with the liquor to be evaporated. The somewhat wide orifice *c*, secured with a screw-plug, serves to admit the hand for the purpose of cleaning it thoroughly out when the operation is finished; *h* is the pipe of communication with the steam boiler; *b* is a tube prolonged and then bent down with its end plunged into the liquor to be evaporated, contained in the charging back, (not shown in the figure). H is a glass tube communicating with the vacuum pan at the top and bottom, to show by the height of the column the quantity of liquid within. The eduction evaporating pipe *c* is provided with a stop-cock to cut off the communication when required. *i* is a tube for the discharge of the air and the water from the steam-case or jacket; the refrigerator E is best formed of thin copper tubes about 1 inch in diameter, arranged zig-zag or spirally like the worm of a still in a cylinder. The small air-tight condenser F, connected with the efflux pipe *f* of the refrigerator, is furnished below with a discharge cock *g*, and surrounded by a cooling case, for the collection of the water condensed by the refrigerator. In its upper part there is a tube *k*, also furnished with a cock, which communicates with the steam boiler, and through which the pan A B is heated.

The operation of this apparatus is as follows: after opening the cocks c, *f*, *i*, and before admitting the cold water into the condenser E, the cock of the pipe *k* is opened, in order that by injecting steam it may expel the included air; after which the cocks *k* and *g* are to be shut. The water must now be introduced into the condenser, and the cock *b* opened, whereon the liquid to be evaporated rises from the charging back, through the tube *b*, and replenishes the vacuum pan to the proper height, as shown by the register glass tube H. Whenever the desired evaporation or concentration is effected, the cock *c* must be closed, the pipe *k* opened, so as to fill the pan with steam, and then the efflux cock *a* is opened to discharge the residuary liquor. By shutting the cocks *a* and *k*, and opening the cock *b*, the pan will charge itself afresh with liquor, and the operation will be begun anew, after *b* has been shut and *c* opened.

The contents of the close water cistern F, may be drawn off during each operation. For this purpose, the cock *f* must first be shut, the cold water is to be then run out of the condenser G, and *k* and *g* are to be opened. The steam entering by *k* makes the water flow, but whenever the steam itself issues from the cock *g*, this orifice must be immediately shut, the cock *f* opened, and the cold water again introduced, whereupon the condensed water that had meanwhile collected in the under part of the refrigerator, flows off into the condenser vessel F. Since some air always enters with the liquor

pan, it must be removed at the time of drawing off the water from the
, by driving steam through the apparatus. This necessity will be less
quor be made to boil before being introduced into the vacuum pan.

ratus may be modified in size and arrangement to suit the peculiar object
t will be perfectly adapted for the concentration of extracts of every kind,
e solutions containing vegetable acids or alkalis. The interior vessel of
made of tinned or plated copper. For an account of Howard's vacuum
i the same principle, see SUGAR.

r is set over a fire, its bottom should not be placed too near the grate, lest
ie flame, and prevent that vivid combustion of the fuel essential to the
iction of heat by its means. The evil influence of leaving too little room
ate and the copper may be illustrated by a very simple experiment. If a
· porcelain capsule containing water be held over the flame of a candle a
e its apex, the flame will suffer no abatement of brightness or size, but
) keep the water briskly boiling. If the capsule be now lowered into the
lame, this will immediately lose its brightness, becoming dull and smoky,
ottom of the capsule with soot; and owing to the imperfect combustion,
er is now surrounded by the flame, its ebullition will cease.

a section of two evaporating coppers *en suite*, so mounted as to favor the

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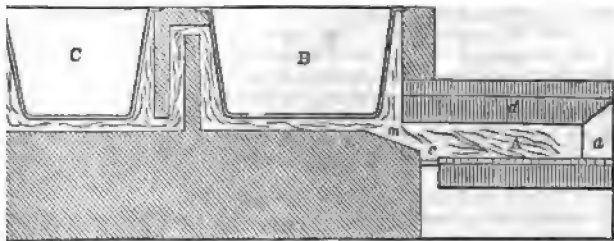
i of the fuel. A is the hearth, in which wood or coal may be burned. For
should be set higher and be somewhat smaller. *a* is the door for feeding
arch of fire-bricks over the hearth; *c*, a grate through which the ashes
t beneath, capable of being closed in front to any extent by a sliding door
e two coppers incased in brickwork; *f* the flue. At the end of the hearth
: the fire plays first upon the copper, the sole is made somewhat lower and
iote the spreading of the flame under the vessel. The second copper, *c*,
enefit of the waste heat; it may be placed upon a higher level, so as to
concentrated liquor by a stop-cock or syphon into the first. When coals
r heating such boilers, the grate should be constructed as shown in the
rewing copper, page 122.

presents a pan for evaporating liquids, which are apt, during concentra-
tion, to let fall crystals or other sediment.
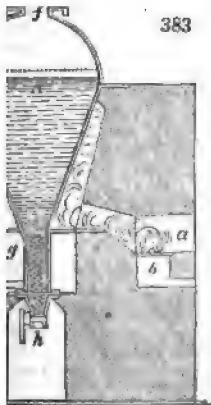
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These would be injured either by the fire play·
ing upon the bottom of the pan, or, by adhesion
to it, they would allow the metal to get red hot,
and in that state run every risk of being burnt
or rent on the sudden intrusion of a little liquor
through the incrustation. When large coppers
have their bottoms planted in loam, so that the
flame circulates in flues round their sides, they
are said to be *cold-set*.

A is a pear-shaped pan, charged with the
liquid to be evaporated; it is furnished with a
dome cover, in which there is an opening with
a flange *f*, for attaching a tube, to conduct the
steam wherever it may be required. *a* is the
fire-place; *b* the ash-pit. The conical part ter-
minates below in the tube *g*, furnished with a
stop-cock at its nozzle *h*. Through the tube
c d c', furnished above and below with the stop-
cocks *c* and *c'*, the liquid is run from the

charging back or reservoir. During the operation, the upper cock c is kept partially open, to replace the fluid as it evaporates; but the under cock c' is shut. The flame from the fire-place plays round the kettle in the space e, and the smoke escapes downwards through the flue i into the chimney. The lower cylindrical part g remains thus comparatively cool, and collects the crystalline or other solid matter. After some time, the under stop-cock c', upon the supply-pipe, is to be opened to admit some of the cold liquor into the cylindrical neck. That cock being again shut, the sediment settled, and the large stop-cock (a horizontal slide-valve would be preferable) h opened, the crystals are suffered to descend into the subjacent receiver; after which the stop-cock h is shut, and the operation is continued. A construction upon this principle is well adapted for heating dyeing coppers, in which the sediment should not be disturbed, or exposed to the action of the fire. The fire-place should be built as for the brewing copper.
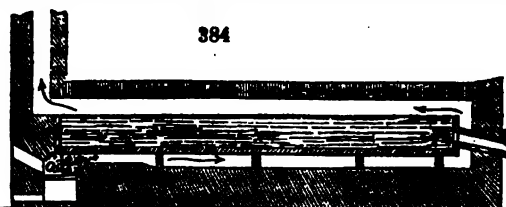
Fig. 384 represents an oblong evaporating pan, in which the flame, after beating along its bottom, turns up at its further end, plays back along its surface, and passes off into the chimney. A is a rectangular vessel, from 10 to 15 feet long, 4 to 6 feet broad, and 1 or 1½ feet deep. The fire-bricks, upon which the pan rests, are so arranged as to distribute the flame equably along its bottom.

EUDIOMETER is the name of any apparatus subservient to the chemical examination of the atmospheric air. It means a *measure of purity*, but it is employed merely to determine the proportion of oxygen which it may contain. The explosive eudiometer, in which about two measures of hydrogen are introduced into a graduated glass tube, containing five measures of atmospheric air, and an electric spark is passed across the mixture, is the best of all eudiometers; and of these the syphon form, proposed by me in a paper published by the Royal Society of Edinburgh in 1819, is probably the surest and most convenient. Volta's explosive eudiometer, as made in Paris, costs 3 guineas; mine may be had nicely graduated for 6 or 8 shillings.

EXPANSION (Eng. and Fr.; *Ausdehnung*, Germ.) is the increase of bulk experienced by all bodies when heated, unless a change of chemical texture take place, as in the case of clays in the potter's kiln. Table i. exhibits the linear expansion of several solids by an increase of temperature from 32° to 212° Fahr.; Table II. exhibits the expansion in bulk of certain liquids.

TABLE I.—*Linear Dilatation of Solids by Heat.*
Dimensions which a bar takes at 212°, whose length at 32° is 1·000000.

Substances.	Authority.	Dilatation in Decimals.	Dilatation in Vulgar Fractions.
Glass tube	Smeaton	1·00083333	
do.	Roy	1·00077615	
do.	Deluc's mean	1·00082800	$\frac{1}{1210}$
do.	Dulong and Petit	1·00086130	$\frac{1}{1147}$
do.	Lavoisier and Laplace	1·00081166	$\frac{1}{1232}$
Plate glass	do. do.	1·000890890	$\frac{1}{1142}$
do. crown glass	do. do.	1·00087572	$\frac{1}{1114}$
do. do.	do. do.	1·00089760	1090
do. do.	do. do.	1·00091751	
do. rod	Roy	1·00080787	
Deal	Roy, as glass	—	
Platina	Borda	1·00085655	
do.	Dulong and Petit	1·00088420	$\frac{1}{1131}$
do.	Troughton	1·00099180	
do. and glass	Berthoud	1·00110000	
Palladium	Wollaston	1·00100000	
Antimony	Smeaton	1·00108300	
Cast-iron prism	Roy	1·00110940	
Cast-iron	Lavoisier, by Dr Young	1·00111111	
Steel	Troughton	1·00118990	

Substances.	Authority.	Dilatation in Decimals.	Dilatation in Vulgar Fractions.
Steel rod - - -● - -	Roy - - -	1·00114470	
Blistered Steel - - - -	Phil. Trans. 1795, 428	1·00112500	
do. - - - -	Smeaton - - -	1·00115000	
Steel not tempered - - -	Lavoisier and Laplace	1·00107875	$\frac{1}{927}$
do. do. - - -	do. do.	1·00107956	$\frac{1}{926}$
do. tempered yellow - - -	do. do.	1·00136900	
do. do. do. - -	do. do.	1·00138600	
do. do. do. at a higher heat	do. do.	1·00123956	$\frac{1}{807}$
Steel - - - - -	Troughton - -	1·00118980	
Hard Steel - - - -	Smeaton - - -	1·00122500	
Annealed steel - - -	Muschenbroek -	1·00122000	
Tempered steel - - -	do.	1·00137000	
Iron - - - - -	Borda - - -	1·00115600	
do. - - - - -	Smeaton - - -	1·00125800	
Soft iron, forged - - -	Lavoisier and Laplace	1·00122045	
Round iron, wire drawn - -	do. do.	1·00123504	
Iron wire - - - -	Troughton - -	1·00114010	
Iron - - - - -	Dulong and Petit	1·00118203	$\frac{1}{846}$
Bismuth - - - -	Smeaton - - -	1·00139200	
Annealed gold - - -	Muschenbroek -	1·00146000	
Gold - - - - -	Ellicot, by comparison	1·00150000	
do. procured by parting - -	Lavoisier and Laplace	1·00146606	$\frac{1}{682}$
do. Paris standard, unannealed -	do. do.	1·00155155	$\frac{1}{645}$
do. do. annealed -	do. do.	1·00151361	$\frac{1}{661}$
Copper - - - -	Muschenbroek -	1·0019100	
do. - - - - -	Lavoisier and Laplace	1·00172244	$\frac{1}{581}$
do. - - - - -	do. do.	1·00171222	$\frac{1}{584}$
do. - - - - -	Troughton - -	1·00191880	
do. - - - - -	Dulong and Petit	1·00171821	$\frac{1}{582}$
Brass - - - - -	Borda - - -	1·00178300	
do. - - - - -	Lavoisier and Laplace	1·00186671	
do. - - - - -	do. do.	1·00188971	
Brass scale, supposed from Hamburg	Roy - - -	1·00185510	
Cast brass - - - -	Smeaton - - -	1·00187500	
English plate-brass, in rod -	Roy - - -	1·00189280	
do. do. in a trough form	do. - - -	1·00189190	
Brass - - - - -	Troughton - -	1·00191880	
Brass wire - - - -	Smeaton - - -	1·00193000	
Brass - - - - -	Muschenbroek -	1·00216000	
Copper 8, tin 1 - - -	Smeaton - - -	1·00181700	
Silver - - - - -	Herbert - -	1·00189000	
do. - - - - -	Ellicot, by comparison	1·0021000	
do. - - - - -	Muschenbroek -	1·00212000	
do. of cupel - - -	Lavoisier and Laplace	1·00190974	$\frac{1}{524}$
do. Paris standard - - -	do. do.	1·00190868	$\frac{1}{524}$
Silver - - - - -	Troughton - -	1·0020826	
Brass 16, tin 1 - - -	Smeaton - - -	1·00190800	
Speculum metal - - -	do. - - -	1·00193300	
Spelter solder; brass 2, zinc 1 -	do. - - -	1·00205800	
Malacca tin - - -	Lavoisier and Laplace	1·00193765	$\frac{1}{515}$
Tin from Falmouth - -	do. do.	1·00217298	$\frac{1}{462}$
Fine pewter - - -	Smeaton - - -	1·00228300	
Grain tin - - - -	do. - - -	1·00248300	
Tin - - - - -	Muschenbroek -	1·00281000	
Soft solder; lead 2, tin 1 - -	Smeaton - - -	1·00250800	
Zinc 8, tin 1, a little hammered -	do. - - -	1·00269200	
Lead - - - - -	Lavoisier and Laplace	1·00284836	$\frac{1}{351}$
do. - - - - -	Smeaton - - -	1·00286700	
Zinc - - - - -	do. - - -	1·00294200	
Zinc, hammered out ½ inch per foot	do. - - -	1·00301100	
Glass, from 32° to 212° - -	Dulong and Petit -	1·00086130	$\frac{1}{1161}$
do. from 212° to 392° - -	do. do.	1·00091827	$\frac{1}{1089}$
do. from 392° to 572° - -	do. do. -	1·000101114	$\frac{1}{947}$

The last two measurements by an air thermometer.

TABLE II.

Expansion of certain Liquids by being Heated from 32° to 212°.

Substances.	Authority.		Expansion in Decimals.	Expansion in Vulgar Fractions
Mercury - - - -	Dulong and Petit	-	0·01801800	$\frac{1}{55\frac{1}{2}}$
do. in glass - - -	do. do.	-	0·01543200	$\frac{1}{64}$
Water, from its maximum density	Kirwan	-	0·04332	$\frac{1}{23}$
Muriatic acid (sp. gr. 1·137) -	Dalton	-	0·0600	$\frac{1}{17}$
Nitric acid (sp. gr. 1·40) -	do.	-	0·1100	$\frac{1}{9}$
Sulphuric acid (sp. gr. 1·85) -	do.	-	0·0600	$\frac{1}{17}$
Alcohol (to its boiling point) ? -	do.	-	0·1100	$\frac{1}{9}$
Water - - - -	do.	-	0·0460	$\frac{1}{22}$
Water, saturated with common salt	do.	-	0·0500	$\frac{1}{20}$
Sulphuric ether (to its boiling point) ?	do.	-	0·0700	$\frac{1}{13}$
Fixed oils - - -	do.	-	0·0800	$\frac{1}{12\frac{1}{2}}$
Oil of turpentine - - -	do.	-	0·0700	$\frac{1}{14}$

If the density of water at 39° be called - - - 1·00000,
at 212° it becomes - - - 0·9548,
and its volume has increased to - - 1·04734;
at 77° it becomes - - - - 0·9973587,
and its volume has increased to only - 1·00265,
which, though one fourth of the whole range of temperature, is only $\frac{1}{18}$ of the total expansion. Water at 60° F. has a specific gravity of - 0·9991953,
and has increased in volume from 39° to - 1·00008,
which is only about $\frac{1}{58}$ of the total expansion to 212°, with $\frac{1}{64}$ of the total range of temperature.

All gases expand the same quantity by the same increase of temperature, which from 32° to 212° Fahr. = $\frac{180°}{480} = \frac{3}{8}$, or 100 volumes become 1·375. For each degree of Fahr. the expansion is $\frac{1}{480}$.

When dry air is saturated with moisture, its bulk increases, and its specific gravity diminishes, because aqueous vapor is less dense than air, at like temperatures.

The following table gives the multipliers to be employed for converting one volume of moist gas at the several temperatures into a volume of dry gas.

Temperature.	Multiplier.	Temperature.	Multiplier.
53° F.	0·9870	64°	0·9799
54	0·9864	65	0·9793
55	0·9858	66	0·9786
56	0·9852	67	0·9779
57	0·9846	68	0·9772
58	0·9839	69	0·9765
59	0·9833	70	0·9758
60	0·9827	71	0·9751
61	0·9820	72	0·9743
62	0·9813	73	0·9735
63	0·9806		

EXTRACTS. (*Extraits*, Fr.; *Extracten*, Germ.) The older apothecaries used this term to designate the product of the evaporation of any vegetable juice, infusion, or decoction; whether the latter two were made with water, alcohol, or ether; whence arose the distinction of aqueous, alcoholic, and ethereous extracts.

Fourcroy made many researches upon these preparations, and supposed that they had all a common basis, which he called the *extractive* principle. But Chevreul and other chemists have since proved that this pretended principle is a heterogeneous and very variable compound. By the term *extract*, therefore, is now meant merely the whole of the soluble matters obtained from vegetables, reduced by careful evaporation to either a pasty or solid consistence. The watery extracts, which are those most commonly made, are as various as the vegetables which yield them; some containing chiefly sugar or gum in great abundance, and are therefore innocent or inert; while others contain very energetic impregnations. The conduct of the evaporating heat is the capital point in the preparation of extracts. They should be always prepared, if possible, from the juice of the fresh plant, by subjecting its leaves or other succulent

ı of a powerful screw or hydraulic press; and the evaporation should
e warmth of a water-bath, heated not beyond 100° or 120° F. Steam
s be applied advantageously in some cases, where it is not likely to
ʳ the principles of the plant. But by far the best process for·making
uo, upon the principles explained in the article EVAPORATION. It is
t up a proper apparatus of this kind, than most practical men imagine.
ʹ either be made through the agency of steam, as there pointed out, or
air-pump. One powerful air-pump may form and maintain a good
veral receivers, placed upon the flat-ground flanges of so many basins,
th a stop-cock at its side for exhaustion. The airless basin containing
et on the shelf of a water-bath, and exposed to a proper temperature,
short time, a large quantity of medicinal extract, possessing the prop-
t unimpaired.
y delicate purposes, the concentration may be performed in the cold, by
illed with the expressed juice over a basin containing sulphuric acid,
ceiver over them and exhausting its air.

F.

ʰray copper-ore, called also Panabase, from the many oxydes it contains.
ʰ name of the impure spirit, which comes over first and last in the distil-
ʳ; the former being called the *strong*, and the latter, which is much
the *weak* faints. This crude spirit is much impregnated with fetid
ʰerefore very unwholesome, and must be purified by rectification.
ʰ, Fr.; *Fächer*, Germ.) is usually a semi-circular piece of silk or paper,
ʰclosing slender slips of wood, ivory, tortoise-shell, whale-bone, &c.,
tail of a peacock, in a radiating form, and susceptible of being folded
anded at pleasure. This well-known hand ornament is used by ladies
s by agitating the air. Fans made of feathers, like the wing of a bird,
ʳed from time immemorial by the natives of tropical countries.
ʰ name of the apparatus for winnowing corn. For an account of the
ʰ and ventilating fan machine, see FOUNDRY and VENTILATOR.
rine, Fr.; *Mehl*, Germ.) is the flour of any species of corn, or starchy
ıto, arrow root, &c. See BREAD and STARCH.
ıes, Fr.; *Fette*, Germ.) occur in a great number of the animal
ındant under the skin in what is called the cellular membrane, round
e folds of the omentum, at the base of the heart, in the mediastinum,
ebb, as well as upon the surface of the intestines, and among many of
hey vary in consistence, color, and smell, according to the animals
are obtained; thus, they are generally fluid in the cetaceous tribes,
ʳored in the carnivorous, solid and nearly scentless in the ruminants,
l copious in well-fed young animals; yellowish and more scanty in the
istence varies also according to the organ of their production; being
skin, and in the neighborhood of the kidneys, than among the moveable
ms about one twentieth of the weight of a healthy animal. But as
butcher it is not pure, for being of a vesicular structure, it is always
ıranes, mixed with blood, blood-vessels, lymphatics, &c. These foreign
t be separated in some measure mechanically, after the fat is minced
nore completely by melting it along with hot water, passing it through
ıg the whole cool very slowly. By this means a cake of cleansed fat
Many plans of purifying fats have been proposed; one of the best is
ʰent. of strong sulphuric acid with a quantity of water, in which the
for some time with much stirring; to allow the materials to cool, to
rnatant fat, and re-melt it with abundance of hot water. More tallow
ned, and that considerably whiter and harder than is usually procured

ıat chlorine and chloride of lime do not improve, but rather deterio-
ınce of oils and other fatty bodies. According to Appert, minced suet
ıction of high-pressure steam in a digester, at 250° or 260° F., becomes
ʲonorous when struck, whiter, and capable, when made into candles, of
light. A convenient mode of *rendering* minced tallow, or melting it, is
ı, and drive steam through it from numerous orifices in ramifying pipes
ottom. Mr. Watt assures me that his plan of purifying fats, patented
ıas been quite successful. He employs dilute sulphuric acid, to which
ıtric acid, with a very small quantity of bichromate of potash, " to sup-

ply oxygen," and some oxalic acid. These are mixed with the fat in the steaming tub. When the lumps of it are nearly dissolved, he takes for every ton of fat, one pound of strong nitric acid, diluted with one quart of water; to which he adds two ounces of alcohol, naptha, sulphuric ether, or spirits of turpentine; and after introducing this mixture, he continues the boiling for half an hour. The fat is finally washed.—As I do not comprehend the *modus operandi* of these ingredients, I shall abstain from any comment upon the recipe.

Others have proposed to use vegetable or animal charcoal first, especially for rancid oils, then to heat them with a solution of sulphate of copper and common salt, which is supposed to precipitate the fetid albuminous matter. Milk of lime has been also prescribed; but it is, I believe, always detrimental.

Davidson treats whale oil with infusion of tan, in order to separate the gelatine and albumine in flocks; next with water and chloride of lime, to destroy the smell; and lastly, with dilute sulphuric acid, to precipitate all the lime in the state of a sulphate. This is certainly one of the cheapest and most effective methods of purifying that substance.

Braconnot and Raspail have shown that solid animal fats are composed of very small, microscopic, partly polygonal, partly reniform particles, which are connected together by very thin membranes. These may be ruptured by mechanical means, then separated by triturating the fresh fats with cold water, and passing the unctuous matter through a sieve. The particles float in the water, but eventually collect in a white granular crystalline appearance, like starch. Each of them consists of a vesicular integument, of the nature of stearine, and an interior fluid like elaine, which afterwards exudes. The granules float in the water, but subside in spirits of wine. * When digested in strong alcohol, the liquid part dissolves, but the solid remains. These particles differ in shape and size, as obtained from different animals; those of the calf, ox, sheep, are polygonal, from $\frac{1}{30}$ to $\frac{1}{350}$ of an inch in diameter; those of the sow are kidney-shaped, and from $\frac{1}{30}$ to $\frac{1}{100}$; those of man are polygonal, and from $\frac{1}{30}$ to $\frac{1}{600}$; those of insects are spherical, and at most $\frac{1}{500}$ of an inch.

Fats all melt at a temperature much under 212° F. When strongly heated with contact of air, they diffuse white pungent fumes, then blacken, and take fire. When subjected to distillation, they afford a changed fluid oil, carbureted hydrogen, and the other products of oily bodies. Exposed for a certain time to the atmosphere, they become rancid, and generate the same fat acids as they do by saponification. In their fresh state they are all composed principally of stearine, margarine, and oleine, with a little coloring and odorous matter; and, in some species, hircine, from the goat; phocenine, from the dolphin; and butyrine, from butter. By subjecting them to a great degree of cold, and compressing them between folds of blotting paper, a residuum is obtained, consisting chiefly of stearine and margarine; the latter of which may be dissolved out by oil of turpentine.

Beef and Mutton Suet.—When fresh, this is an insipid, nearly inodorous fat, of a firm consistence, almost insoluble in alcohol, entirely so if taken from the kidneys and mesenteric web of the ox, the sheep, the goat, and the stag. It varies in its whiteness, consistence, and combustibility, with the species and health of the animals. That of the sheep is very white and very solid. They may all be purified in the manner above described. Strong sulphuric acid developes readily the acid fats by stirring it through melted suet. Alkalis, by saponification, give rise at once to the three acids,—the stearic, margaric, and oleic. Beef suet consists of stearine, margarine, and oleine; mutton and goat suet contain a little hircine. The specific gravity of the tallow of which common candles are made is, by my experiments, 0·936. The melting point of suet is from 98° to 104° F. The proportion of solid and fluid fat in it is somewhat variable, but the former is in much larger proportion. Mutton suet is soluble in 44 parts of boiling alcohol, of 0·820; beef suet in 41 parts. Marrow fat consists of 76 of stearine, and 24 of oleine; it melts at 115° F.

Hog's-lard is soft, fusible at 81° F., convertible, by an alkaline solution, into a stearate, margarate, oleate, and glycerine. Its sp. grav. is 0·938, at 50° F. It consists of 62 of oleine, and 38 of stearine, in 100 parts.

Goose-fat consists of 68 oleine and 32 stearine.

Butter, in summer, consists of 60 of oleine and 40 of stearine; in winter, of 35 of oleine, and 65 of stearine; the former substance being yellow, and the latter white. It differs, however, as produced from the milk of different cows, and also according to their pasture.

The ultimate constituents of stearine, according to Chevreul, are 79 carbon, 11·7 hydrogen, and 9·3 oxygen, in 100 parts.

1,294,009 cwts. of the tallow imported in 1837 were retained for internal consumption. See MARGARINE, OLEINE, SOAP, STEARINE.

FAULTS (*Failles,* Fr.), in mining, are disturbances of the strata which interrupt

the miner's operations, and put him at *fault*, to discover where the vein of ore or bed of coal has been thrown by the convulsions of nature. Many examples of faults are exhibited under Prrcoal.

FEATHERS (*Plumes*, Fr.; *Federn*, Germ.) constitute the subject of the manufacture of the *Plumassier*, a name given by the French (and also the English) to the artisan who prepares the feathers of certain birds for ornaments to the toilet of ladies and for military men, and to him also who combines the feathers in various forms. We shall content ourselves with describing the method of preparing ostrich feathers, as most others are prepared in the same way.

Several qualities are distinguished in the feathers of the ostrich; those of the male, in particular, are whiter and more beautiful. Those upon the back and above the wings are preferred; next, those of the wings, and lastly, of the tail. The down is merely the feathers of the other parts of the body, which vary in length from 4 to 14 inches. This down is black in the males, and gray in the females. The finest white feathers of the female have always their ends a little grayish, which lessens their lustre, and lowers their price. These feathers are imported from Algiers, Tunis, Alexandria, Madagascar, and Senegal; this being the order of their value.

The *scouring process* is thus performed:—4 ounces of white soap, cut small, are dissolved in 4 pounds of water, moderately hot, in a large basin; and the solution is made into a lather by beating with rods. Two bundles of the feathers, tied with packthread, are then introduced, and are rubbed well with the hands for five or six minutes. After this soaping they are washed in clear water, as hot as the hand can bear.

The whitening or bleaching is performed by three successive operations.

1. They are immersed in hot water mixed with Spanish white, and well agitated in it; after which they are washed in three waters in succession.

2. The feathers are azured in cold water containing a little indigo tied up in a fine cloth. They should be passed quickly through this bath.

3. They are sulphured in the same way as straw hats are (See Sulphuring); they are then dried by hanging upon cords, when they must be well shaken from time to time to open the fibres.

The ribs are scraped with a bit of glass cut circularly, in order to render them very pliant. By drawing the edge of a blunt knife over the filaments they assume the curly form so much admired. The hairs of a dingy color are dyed black. For 20 pounds of feathers, a strong decoction is made of 25 pounds of logwood in a proper quantity of water. After boiling it for 6 hours, the wood is taken out, 3 pounds of copperas are thrown in; and, after continuing the ebullition for 15 or 20 minutes, the copper is taken from the fire. The feathers are then immersed by handfuls, thoroughly soaked, and worked about; and left in for two or three days. They are next cleansed in a very weak alkaline ley, and soaped three several times. When they feel very soft to the touch, they must be rinsed in cold water, and afterwards dried. White feathers are very difficult to dye a beautiful black. The acetate of iron is said to answer better than the sulphate, as a mordant.

For dying other colors, the feathers should be previously well bleached by the action of the sun and the dew; the end of the tube being cut sharp like a toothpick, and the feathers being planted singly in the grass. After fifteen days' exposure, they are cleared with soap as above described.

Rose color or *pink*, is given with safflower and lemon juice.

Deep red, by a boiling hot bath of Brazil wood, after aluming.

Crimson. The above deep red feathers are passed through a bath of cudbear.

Prune de Monsieur. The deep red is passed through an alkaline bath.

Blues of every shade, are dyed with the indigo vat.

Yellow; after aluming, with a bath of turmeric or weld.

Other tints may be obtained by a mixture of the above dyes.

Feathers have some more useful employments than the decoration of the heads of women and soldiers. In one case, they supply us with a soft elastic down on which we can repose our wearied frames, and enjoy sweet slumbers. Such are called *bed* feathers. Others are employed for writing, and these are called *quills*.

Goose feathers are most esteemed for beds, and they are best when plucked from the living bird, which is done thrice a year, in spring, midsummer, and the beginning of harvest. The qualities sought for in bed feathers, are softness, elasticity, lightness, and warmth. Their only preparation when cleanly gathered is a slight beating to clear away the loose matter, but for this purpose they must be first well dried either by the sun or a stove. Bleaching with lime water is a bad thing, as they never can be freed from white dust afterwards.

The feathers of the eider duck, *anas mollissima*, called eider down, possess in a superior degree all the good qualities of goose down. It is used only as a covering to beds, and never should be slept upon, as it thereby loses its elasticity.

Quills for writing. These consist usually of the feathers plucked out of the wings of geese. Dutch quills have been highly esteemed, as the Dutch were the first who hit upon the art of preparing them well, by clearing them both inside and outside from a fatty humor with which they are naturally impregnated, and which prevents the ink from flowing freely along the pens made with them. The Dutch for a long time employed hot cinders or ashes to attain this end; and their secret was preserved very carefully, but it at length transpired, and the process was then improved. A bath of very fine sand must be kept constantly at a suitable temperature, which is about 140° F.; into this, the quill end of the feather must be plunged, and left in it a few instants. On taking them out they must be strongly rubbed with a piece of flannel, after which they are found to be white and transparent. Both carbonate of potash in solution and dilute sulphuric acid have been tried to effect the same end, but without success. The yellow tint which gives quills the air of age, is produced by dipping them for a little in dilute muriatic acid, and then making them perfectly dry. But this process must be preceded by the sand-bath operation. The above is the French process.

Quills are dressed by the London dealers in two ways; by the one, they remain of their natural color; by the other, they acquire a yellow tint. The former is called the Dutch method, and the principal workman is called a Dutcher. He sits before a small stove fire, into which he thrusts the barrel of the quill for about a second, then lays its root quickly below his blunt-edged knife called a hook, and, pressing this firmly with the left hand, draws the quill briskly through with his right. The bed on which the quill is laid to receive this pressure is called the plate. It is a rectangular smooth lump of iron, about 3 inches long, 1½ broad, and 2½ thick, which is heated on his stove to about the 350th degree Fahr. The hook is a ruler of about 15 inches in length, somewhat like the pattenmaker's knife, its fulcrum being formed at the one end by a hook and staple, and the power of pressure being applied by the hand at the other end. The quill, rendered soft and elastic by the heat, endures the strong scraping action of the tool, and thus gets stripped of its opaque outer membrane, without hazard of being split. A skilful workman can pass 2000 quills through his hands in a day of 10 hours.

They are next cleaned by being scrubbed by a woman with a piece of rough dog-fish skin, and finally tied up by a man in one quarter of a hundred bundles.

In another mode of dressing quills, they are steeped a night in decoction of turmeric, to stain them yellow; taken out and dried in warm sand contained in a pot, then scraped by the Dutcher as above described. The first are reckoned to make the best pens, though the second may appear more beautiful.

Crow quills for draughtsmen, as well as swan quills, are prepared in the same way. The quills plucked from well-fed living birds have most elasticity, and are least subject to be moth-eaten. The best are those plucked, or which are spontaneously cast in the month of May or June, because they are then fully ripe. In the goose's wing the five exterior feathers only are valuable for writing. The first is the hardest and roundest of all, but the shortest. The next two are the best of the five. They are sorted into those of the right and the left wing, which are differently bent. The heaviest quills are, generally speaking, the best. Lately, steaming for four hours has been proposed as a good preparation.

FECULA (*Fecule*, Fr.; *Stärkemehl*, Germ.) sometimes signifies corn flour, sometimes starch from whatever source obtained.

FELDSPAR (*Orthose*, Fr.; *Feldspath*, Germ.) is a mineral crystallizing in oblique rhomboidal prisms, susceptible of two clivages; lustre more pearly than vitreous; spec. grav. 2·39 to 2·58; scratches glass; yields no water when calcined; fusible at the blowpipe into a white enamel; not affected by acids. The liquid left from its analytical treatment with nitrate of baryta, nitric acid, and carbonate of ammonia, affords on evaporation an alkaline residuum which precipitates platina from its chloride, and appears from this, as well as other tests, to be potash. Feldspar consists of—silica, 66·75; alumina, 17·50; potash, 12; lime, 1·25; oxyde of iron, 0·75. *Rose.* This mineral is a leading constituent of granite; and in its decomposed state furnishes the petuntse or Cornish stone, so much used in the porcelain and best pottery manufactures.

FELTING (*Feutrage*, Fr.; *Filzen*, Germ.) is the process by which loose flocks of wool, and hairs of various animals, as the beaver, rabbit, hare, &c., are mutually interlaced into a compact textile fabric. The first step towards making felt is to mix, in the proper proportions, the different kinds of fibres intended to form the stuff; and then, by the vibratory strokes of the bowstring, to toss them up in the air, and to cause them to fall as irregularly as possible, upon the table, opened, spread, and scattered. The workman covers this layer of loose flocks with a piece of thick blanket stuff slightly moistened; he presses it with his hands, moving the hairs backwards and forwards in all directions. Thus the different fibres get interlaced, by their ends pursuing ever tortuous paths; their vermicular motion being always, however, root foremost. As the

matting gets denser, the hand pressure should be increased in order to overcome the in-
reasing resistance to the decussation.

A first thin sheet of soft spongy felt being now formed, a second is condensed upon it
n like manner, and then a third, till the requisite strength and thickness be obtained.
These different pieces are successively brought together disposed in a way suitable to the
wished-for article, and united by continued dexterous pressure. The stuff must be next
subjected to the fulling-mill. See HAT MANUFACTURE.

FERMENT (Eng. and Fr.; *Hefe*, Germ.) is the substance which, when added in a
small quantity to vegetable or animal fluids, tends to excite those intestine motions and
changes which accompany fermentation. It seems to be the result of an alteration which
vegetable albumen and gluten undergo with contact of air amidst a fermenting mass.
The precipitate or lees which fall down when fermentation is finished consist of a mix-
ture of the fermenting principle with the insoluble matters contained in the fermented
liquor, some of which, like hordeine, existed in the worts, and others are probably genera-
ted at the time.

To prepare a pure ferment, or at least a compound rich in that principle, the precipi-
tate separated during the fermentation of a clear infusion of malt, commonly called
yeast or barm, is made use of. This pasty matter must be washed in cold distilled water,
drained and squeezed between the folds of blotting paper. By this treatment it becomes
a pulverulent mass, composed of small transparent grains, yellowish gray when viewed
in the compound microscope. It contains much water, and is therefore soft, like moist
gluten and albumen. When dried, it becomes like these bodies, translucid, yellowish
brown, horny, hard, and brittle. In the soft humid state it is insipid, inodorous, in-
soluble in water and alcohol. If, in this state, the *ferment* be left to itself at a tempera-
ture of from 60° to 70° F., but not in too dry a situation, it putrefies with the same phe-
nomena as vegetable gluten and albumen, and leaves, like them, a residuum resembling
old cheese.

At the beginning of this change, particularly if the ferment be enclosed in a limited
portion of air, there is an absorption of oxygen gas with a fivefold disengagement of car-
bonic acid gas; while acetic acid makes its appearance in the substance. When distilled
by itself it affords the same products as gluten. Dilute acids dissolve it very readily;
and so does potash with the production of ammonia, a peculiar circumstance, for in dis-
solving gluten the alkali causes no such evolution.

The property possessed by yeast of determining the fermentation of a properly diluted
solution of sugar is very fleeting, and is lost by very trifling alterations. It is destroyed
by complete desiccation, and cannot be restored by moistening it again. The attempts
made in London to squeeze out the liquid part of yeast in bags placed in a powerful press,
and to obtain a solid cake, in order to transport ferment to India, have had but a very
partial success; for its virtue is so impaired that it will rarely excite a perfect fermenta-
tion in the best prepared worts. The same method is adopted in Germany, to send yeast
to only moderate distances; and therefore with more advantage.

If yeast be boiled for ten minutes, it loses the greater part of its fermenting power,
and by longer boiling it becomes inert.

When alcohol is poured upon yeast, it immediately destroys its fermenting faculties,
though, on filtering it off, it seems to carry no remarkable principle with it. One thou-
sandth part of sulphuric acid equally deprives yeast of its peculiar property, and so does
a little strong acetic acid. All the acids and the salts, especially those which part readily
with their oxygen, produce the same effect. A very small quantity of sulphurous acid,
or sulphites, mustard powder, particularly the volatile oil of mustard, and in general the
volatile oils that contain sulphur, as well as the vegetables which yield them, such as
horse-radish and garlic, all kill the fermenting agent. Lastly, fermentation is completely
stopped by a moderate depression of temperature.

During fermentation the yeast undergoes a change; it loses the property of causing
another wort to ferment. This change probably depends upon the chemical reaction
between the ferment and the sugar that is decomposed; for a certain quantity of yeast
can effect the fermentation of only a certain quantity of sugar, and all the sugar exceed-
ing this quantity remains unaltered in the liquor. It has been concluded from some rath-
er loose experiments, that one part and a half of yeast (supposed to be in the dry state)
is adequate to the fermentation of a solution of 100 parts of pure sugar. When such
a solution is fermented by the precise proportion of yeast, the fermenting principle is ex-
hausted, for no new yeast is formed in it. There is a deposite indeed to about half the
weight of the yeast employed, of a white matter insoluble in water, which affords no am-
monia by dry distillation, and is incapable of acting as a ferment upon a fresh saccharine
solution.

Of all the bodies convertible into yeast during fermentation, vegetable gluten
and albumen possess the most rapid and energetic powers. But ordinary glue, ising-
glass, animal fibrine, curd or *caseum*, albumine, urine, and other azotized substances, all

enjoy the property of causing a solution of sugar to ferment; with this difference, that whilst yeast can establish a complete fermentation in less than an hour, at a temperature of about 68°, the above substances require several days, with a heat of from 77° to 87° F., for becoming ferments, and for occasioning fermentation. Substances devoid of nitrogen do not produce a ferment.

FERMENTATION. (Eng. and Fr.; *Gahrung*, Germ.) When organic substances, under the influence of water, air, and warmth, are abandoned to the reciprocal operation of their proximate principles (sugar, starch, gluten, &c.), they are entirely changed and decomposed, so that their ultimate principles (oxygen, hydrogen, carbon, and in some cases azote) combine in new proportions, and thus give birth to various new compounds. To this process, the general name of fermentation has been given. These operations and their products differ according to the differences of the substances, and of the circumstances in which they are placed. The following may be enumerated as sufficiently distinct species of fermentation. 1. The *saccharine* fermentation, in which starch and gum are changed into sugar. 2. The *vinous* fermentation, in which sugar is converted into alcohol. 3. The *mucilaginous* fermentation, in which sugar is converted into slime, instead of alcohol. 4. The *acetous* fermentation, in which alcohol and other substances are converted into vinegar. 5. The putrid fermentation or putrefaction, which characterises particularly the decomposition of azotized organic substances.

1. *The saccharine fermentation.* When a paste made by boiling one part of starch with twelve parts of water is left entirely to itself, water merely being stirred in as it evaporates, at the end of a month or two in summer weather it is changed into sugar, equal in weight to from one third to one half of the starch, and into gum, equal to from one fifth to one tenth, with a residuum of starch paste somewhat altered. This saccharifying process advances much quicker through the co-operation of vegetable albumine or gluten, acting as a ferment. If we boil two parts of potato starch into a paste with twenty parts of water, mix this paste with one part of the gluten of wheat flour, and set the mixture for 8 hours in a temperature of from 122° to 167° F., the mixture soon loses its pasty character, and becomes by degrees limpid, transparent, and sweet, passing at the same time first into gum, and then into sugar. The remainder consists of the unchanged starch with the altered gluten, which has become sour, and has lost the faculty of acting upon fresh portions of starch. It is probable, however, that the sugar formation in the first case, when the starch undergoes a spontaneous change, may be due to the action of a small portion of gluten and albumine left in the starch, since a putrefactive smell is eventually evolved indicative of that azotized matter. The gum into which during this process the starch is first converted, and which becomes afterwards sugar, is of the same nature as British gum, formed by the roasting of starch.

This production of sugar takes place in the germination and kiln-drying of malt; and the mashing of the brewer as well as the sweetening of bread in baking, rests upon the same principles. In many cases the vinous fermentation precedes the saccharification, or accompanies it; the starchy parts of the fermenting mass changing into sugar, while the previously formed sugar becomes wine or beer. In the sweetening of fruits by keeping, a similar process occurs; the gummy and starchy fibres become sugar from the action of the glutinous ferment which they contain; as happens also to the juices of many fruits which sweeten for a little while after they have been expressed.

The nature of this sugar formation through the influence of gluten upon starch, is undoubtedly the same as the conversion of starch into sugar, by boiling it with sulphuric acid; though the whole theory of this change is not entirely developed.

The most energetic substance for the conversion of starch into sugar, is the malt of barley. According to the researches of Payen and Persoz, the gum which by this process is first formed, may be prevented from going into sugar, by merely exposing it to a boiling heat, and hence we have it in our power either to make sugar or gum at pleasure. Of finely ground malt from 10 to 25 parts must be taken for 100 parts of starch. Into a pan placed in a water bath, 400 parts of water being warmed to from 77° to 86° F., the ground malt must be stirred in, and the temperature must be raised to 140°. The 100 parts of starch must now be added, and well mixed. The heat is then to be increased to 158° F.; and be so regulated that it shall not fall below 149°, nor rise above 167°. In the course of 20 or 30 minutes the originally milky and pasty liquid will become gradually more attenuated, and eventually it will turn as fluid nearly as water. This is the point of time in which the starch has passed into gum, or into the substance lately denominated *dextrine* by the chemists. Should this mucilaginous matter, which appears to be a mixture of gum and a little starchy sugar, be wished for in that state, the temperature of the liquid must be suddenly raised to the boiling point, whereby the further action of the malt upon it is stopped. But on the other hand if sugar be desired, then the temperature must be steadily maintained at from 158° to 167° for three quarters of an hour, in which time the greater part of the starch will have become

sugar, and from the evaporation of the fluid a starchy sirup will be obtained, entirely similar to that procurable by the action of very dilute sulphuric acid upon starch.

The substance which operates this saccharine change, or the appropriate yeast of the sugar fermentation, which had been previously imagined to be a residuum of gluten or vegetable albumen in the germinated grain, has been traced by Payen and Persoz to a peculiar proximate vegetable principle called by them *diastase*. This substance is generated during the germination of barley, oats, and wheat, and may be obtained separately by infusing the ground malt in a small quantity of cold water, straining off the liquor, then filtering it, and heating the clear solution in a water-bath to the temperature of 158° F. The greater part of the vegetable albumen is thus coagulated, and must be separated by a fresh filtration; the liquid is afterwards treated with alcohol as long as the flocculent precipitate of diastase falls. In order to purify it still more completely from the azotized matter, it may be once more dissolved in water, and again precipitated by alcohol. When dried at a low temperature, it appears as a white solid, which contains no azote, is insoluble in strong alcohol, but dissolves in weak alcohol and water. Its solution is neutral and tasteless; and if left to itself, it changes spontaneously, sooner or later, according to the degree of warmth, and becomes sour. At the temperature of from 149° to 168°, it has the property of converting starch into gum or dextrine, and sugar; and, when sufficiently pure, it does this with such energy, that one part of it is capable of saccharifying 2000 parts of dry starch. It acts the more rapidly the larger its proportion. Whenever the solution of diastase with starch or dextrine has been heated to the boiling point, it loses the property of transforming these substances. One hundred parts of well malted barley appear to contain about one part of this new body.

2. *The Vinous Fermentation.*—In this fermentation the sugar existing in watery solution is, by the operation of the ferment or yeast, converted into alcohol, with disengagement of carbonic acid gas. If we dissolve one part of pure sugar in ten parts of water, and leave the solution in a temperature of from 68° to 77° F., which is that most favorable to fermentation, it will remain unaltered. But if we stir into that solution some beer yeast, the phenomena of fermentation soon appear in the above circumstances; for carbonic acid gas is evolved, with intestine movements of the liquid, and an increase of its temperature. A body of yeast rises to the surface, and exhibits a continual formation and rupture of air bubbles. At length the sugar being in a great measure decomposed, the motions cease, the liquor becomes clear, and instead of being a sirup, it is now a dilute alcohol. The yeast has by this time fallen to the bottom in a somewhat compact form, and of a whitish color, deprived of the property of exciting fermentation in fresh sirup, provided no undue excess of it was added at first, for that alone would remain effective. Experience shows that for the conversion of a determinate quantity of sugar by fermentation, a determinate quantity of yeast is necessary, which has been estimated at about 1½ per cent. in the dry state. When the yeast has been decomposed by fermenting its definite proportion of sugar, it loses its fermentable property, and leaves the excess of sugar unaffected, forming a sweet vinous solution. The same thing happens if the yeast be separated from the wort by a filter in the progress of the fermentation, for then all intestine motion speedily stops, although much saccharine matter remains.

In the juices of sweet fruits, of grapes, for example, the ferment is intimately associated with the sugar. It is at first soluble and inactive, till it absorbs oxygen from the atmosphere, whereby it becomes an operative ferment, but, at the same time, insoluble, so as to precipitate at the end of the process. When the expressed juice of the grape, or must, is enclosed in a vessel out of contact of air, and there subjected to the heat of boiling water, the small portion of oxygen present is rendered inactive, and the liquor experiences no fermentative change. If the grapes be squeezed in an atmosphere deprived of oxygen, and confined in the same, the juice will also remain unaltered. Recently expressed grape juice is limpid, and manifests the commencement of fermentation by the separation of the yeasty substance, which can take place only with access of air. The solution becomes turbid after a certain time, gas begins to be evolved, and the separated ferment decomposes the sugar. At the end of the process the yeast collects at the bottom of the vessel, usually in larger quantity than was sufficient to complete the fermentation; and hence a considerable portion of it possesses still the fermentative faculty. The fermentation itself, when once begun, that is, whenever the yeasty particles are evolved and float in the liquid, for which evolution a very minute quantity of oxygen is sufficient, is thenceforth independent of the contact of air, and goes on as well in close as in open vessels; so that the production of alcohol and carbonic acid depends solely upon the mutual reaction of the ferment and the sugar.

The yeast, which may be obtained tolerably pure from a fine infusion of malt in a state of fermentation, after being washed with cold water to separate the soluble, gummy, and saccharine matter, and after being pressed between folds of blotting paper, constitutes a pulverulent, grayish yellow, granular substance, destitute of both taste and smell, insoluble both in water and alcohol. Cold water dissolves, indeed, only $\frac{1}{400}$, and boiling water very little more.

The essentially operative constituent of yeast is a peculiar azotised matter, which in the wine vat is mixed with some tartar and other salts, and in the beer tun with gum, starch, &c. This animalized substance may be obtained in a separate state, according to Braconnot, by acting upon the washed yeast powder with a weak ley of carbonate of potash, and by decomposing the solution with vinegar, whereby the matter is thrown down in a gelatinous form. The substance thus obtained is insoluble in cold water and alcohol, but dissolves readily in very dilute alkaline leys, and even in lime water. When diffused through water, it assumes a homogeneous aspect, as if it were really dissolved; but when this mixture is heated, the animalized matter coagulates, and separates in thick flocks. In this state it has lost its former properties, being no longer soluble in alkaline leys, even when concentrated. Acids exercise no solvent power over this peculiar matter; they precipitate it from its solutions, as do also the earthy and metallic salts, which, moreover, combine with it. This is also the case with tannin. The combination of the ferment stuff with acids increases the stability of its constitution, and counteracts its tendency to influence solutions of sugar. These properties of the operative principle of yeast explain many of the phenomena of fermentation, as we shall presently see.

The animalized matter of yeast resembles gluten, albumen, caseum, and other azotised substances; if any one of these be put into a saccharine solution ready for fermentation, it will begin to operate a change, when aided by warmth and time, if it be previously decomposed in some measure to facilitate its influence; or if these substances be brought into a slightly putrescent state beforehand, they will cause more speedy fermentation. Thus white of egg, when added to saccharine liquors, requires a period of three weeks, with a temperature of 96° F., before it will excite fermentation; afterwards the excess of the albumen forms a precipitate which may be used instead of yeast upon other sweet worts. The rapidity with which such azotized substances are capable of being converted into ferments of more or less purity and power is very variable; vegetable gluten and albumen being best fitted for this purpose. This conversion is accelerated when the sweet liquor in which the substance is diffused or dissolved has already begun to ferment; whence it appears that the presence of carbonic acid gas, combined with the liquor, is here of singular influence. Upon it, in fact, the formation and elimination of the yeast in fermenting liquors depend.

A solution of pure sugar, which has been made to ferment by the addition of yeast, furnishes no new yeast; but there remains after the process a portion of the yeast originally mixed, in an altered inoperative condition, should its quantity have been exactly adequate to the decomposition of the sugar, or in an operative state, should the quantity have been originally excessive.

But if the fermentable liquor contains vegetable albumen and gluten, as is commonly the case with the sweet juices of fruits and beer worts, these substances become changed into ferments in the course of the fermentation induced by the yeast, and, being superfluous, so to speak, for that particular process, they remain entire at the end, and may be collected for use in other operations.

Upon this principle is founded the increased production of yeast, and the manufacture of what has been called *artificial barm*, in which the fermentation is conducted chiefly with a view to the formation of yeast. To the fermenting mass, those kinds of meal are added, which abound in albumen and gluten, as barley, beans, or wheat, for instance; and the process is similar to the production of a great lump of leaven, from the action of a small piece of it upon dough. The following prescription will illustrate this subject. Take three ounces of bean flour, add to it five quarts of boiling water, and boil the mixture for half an hour. Pour the decoction into a vessel, and stir into it, while hot, 56 ounces of wheaten flour. After the mixture cools to the temperature of 54° F., add to it about two quarts of beer barm, stirring the whole well together. About 24 hours after the commencement of the fermentation, incorporate with the mixture 112 ounces of barley or bean flour, till it becomes a uniform dough, which must be thoroughly kneaded, rolled out into cakes about an inch thick, and cut into pieces of the size of a dollar. These cakelets must be dried upon laths in the sun in favorable weather, and then put up in a dry situation. For use, one of these discs is to be broken into pieces, laid in warm water, and set in a warm place during 12 hours. The soft mass will then serve the purpose of beer yeast.

Or we may mix equal parts of barley malt, wheat malt, and crushed rye, pour water at the temperature of 122° F. over them into a tub till it stand a span above their surface; then stir well together, and allow the whole to remain at rest for a few hours, till it cools to about 65° F. We must now add for each pound of the mingled meal, a quarter of an ounce of beer barm. The tub must be then covered, and preserved at a temperature of 63° F. The husks, as they begin to rise to the surface, in consequence of the fermentation, must be taken off and squeezed through a cloth over the vessel. When the meal comes afterwards to subside to the bottom, the whole must be strained

ınvass bag, and freed from the superfluous moisture by squeezing. The bag
ghy mass must next be surrounded with dry ashes, to remove the remaining
ıd to arrest any further fermentation. This consistent ferment may be used
eer yeast.

ult to prepare an artificial yeast without barm. The best process for this
he following. Take five parts of honey, one part of powdered tartar, and
ı of wheat or barley malt, stir the whole in water of the temperature of 122°
e in a fermenting heat; when the yeast will, as usual, be eliminated.

ıge which gluten or vegetable albumen undergoes in the different kinds of
it becomes a ferment, consists apparently in an oxydation, since analysis
.his ferment contains more oxygen than gluten does.

en already stated that yeast in its liquid condition readily putrefies, and
ıgether useless for the process of fermentation. In order to preserve it for
.t must be dried to such a degree as to resist spontaneous decomposition
.ng its fermentative faculty; but completely dried yeast loses that property,
t recover it by being again moistened. Beer barm may be dried after being
:ral times with cold water, till the last quantity comes off clear; but the in-
ıon must be allowed to settle fully before the water is poured away from it.
ım being freed as much as possible from water, by drainage and pressure
ınel cloths, is to be dried in the shade by a current of warm air as quickly
with the aid of frequent turning over. It must be afterwards kept in dry
ıels. Yeast may also be preserved a short time in activity by being kneaded
ch barley or wheat flour as it can take up without losing the doughy con-
ried yeast has, however, always an impaired activity. The easiest and most
ıod of preserving yeast in its primitive power, is by mixing it, after pressure
ríth as much pulverized sugar as will render it dry, and putting up the mix-
ight vessels. The fermentative power of yeast is destroyed by the following
ıs already stated, by making it completely dry either by the evaporation of
r its abstraction by alcohol; 2. by boiling, which if continued for ten minutes
ıt quite inoperative; 3. by the action of such substances as dissolve out its
ıstituents; by alkalis, for instance, since the particles of yeast seem to be
ly in their insoluble granular state; 4. by such substances as form combina-
, and thereby either alter its nature, or at least increase the cohesion of its
ıarts, so that they can no longer operate upon sweet liquors by the decompo-
of its ultimate particles. Such bodies are the acids, especially the mineral ʼ
and most salts, particularly the metallic, which unite with the yeast into new
  The volatile oils which contain sulphur exercise the same paralyzing influ-
east.

mstances which promote, and are necessary to, the vinous fermentation are,
to the above views, the following :—1. The presence of the proper quantity
ıst, and its proper distribution through the worts. If in the course of a slack
. the yeast subsides to the bottom, the intestine motions cease entirely, but
excited anew by stirring up the ingredients, or rousing the tun, as the brew-
. A certain degree of warmth, which should never be less than 51° F., nor
ı6°; the temperature of from 68° to 77° being the most propitious for the
ent and progress of fermentation. When other circumstances are the same,
of the fermentation is proportional to the temperature within certain limits,
ıwering it, the action may be moderated at pleasure. 3. The fermentation
: better and more equably the greater the mass of fermenting liquor, probably
ıf the uniformly high temperature, as well as the uniform distribution of the
:les of the yeast by the greater energy of the intestine movements. 4. The
.olution must be sufficiently diluted with water; when too much concentrated
erment. Hence very sweet musts furnish wines containing much undecom-
. For a complete fermentative action, one part of sugar should be dissolved
of water.

tion may be tempered or stopped: 1. by those means which render the yeast
particularly by the oils that contain sulphur, as oil of mustard; as also by
ıus and sulphuric acids. The operation of the sulphurous acid in obstructing
ation of must consists partly, no doubt, in its absorbing oxygen, whereby the
of the yeasty particles is prevented. The sulphurous acid, moreover, acts
fully upon fermenting liquors that contain tartar, as grape juice, than sul
  This acid decomposes the tartaric salts, and, combining with their bases,
getable acid free, which does not interfere with the fermentation; but the
acid operates directly upon the yeast: 2. by the separation of the yeast, either
:er or by subsidence: 3. by lowering the temperature to 45° F. If the fer-
.ss become clear at this temperature, and be drawn off from the subsided yeast,
ʼerment again, though it should be heated to the proper pitch.

The products of vinous fermentation are carbonic acid gas, and alcohol; of which the former escapes during the process, except in the case of the sparkling wines, like champaign, that are partially fermented in close vessels. The alcohol remains in the fermented liquor. 100 parts of sugar afford by complete decomposition nearly 50 parts of alcohol. According to Thenard, 100 parts of sugar are converted into 46·8 parts of carbonic acid, and 49·38 of alcohol; besides 3·82 parts of carbon otherwise employed, which the sugar contained, above what is present in the former two products. This chemist found in the fermented liquor 4 per cent. of an extractive matter, soluble in water, and having an acidulous reaction, to whose formation, probably, that excess of carbon may be necessary. In what way the action of the yeasty particles upon the saccharine substance is carried on in the vinous fermentation, or what may be the interior working of this process, is not accurately understood. The quantitative relation of the carbonic acid and alcohol to the sugar is pretty well made out; but the determination of the ultimate principles of the ferment itself, before and after the vinous change, and of the residuum dissolved in the fermented liquor, has not been well ascertained. It is probable that the yeast undergoes in the process a similar decomposition to that of the putrefactive, and that its elementary constituents enter into new combinations, and abstract so much carbon and hydrogen from the sugar, that the remainder, amounting to 96 per cent. of the whole, may constitute one atom of alcohol and one of carbonic acid.

3. *The slimy or glutinous fermentation.*—This process takes place in weak solutions of sugar, at ordinary fermenting temperatures, where, from defect of good yeast, the vinous fermentation cannot proceed. In such circumstances, from one part of sugar, one third part of gum is formed. According to Desfosses, however, 100 parts of sugar afford 109·48 of gum or slime. This is formed when one part of sugar is dissolved in twenty parts of water, which had been previously boiled with washed barm or gluten, and then filtered. The process proceeds slowly and quietly, equally well in close vessels, as with contact of air, and continues at ordinary temperatures about 12 days; but it goes on more rapidly and completely at the heat of from 77° to 86° F. A small quantity of hydrogen and carbonic acid gas is disengaged, in the proportion of two to one by volume. The fermented liquor becomes turbid, and assumes a tough thready appearance, like a decoction of linseed. A small addition of sulphuric or sulphurous acid, of muriatic acid and alum, or of tannin, impedes this species of fermentation; because these substances combine, as in the vinous fermentation, with the ferment into an insoluble precipitate, unsusceptible of further change. In many wines, especially when bottled, this slimy fermentation occurs, and occasions their ropiness, which may be best remedied or prevented by the addition of as much tannin as will precipitate the dissolved mucous matter. This species of fermentation attacks very rapidly the rinsing waters of the sugar refiner, which always contain some fermentative gluten. A little alum is the best preventive in this case, because it precipitates the dissolved ferment.

4. *The acetous or sour fermentation.*—In this process, alcohol, more or less dilute, is resolved into water and vinegar, in consequence of the operation of the ferment; oxydizement of the alcohol being effected by the oxygen of the atmospherical air. The requisites of this process have been already detailed under the article ACETIC ACID. They are the presence of atmospherical air; alcohol diluted to a certain degree with water ferment or yeast, and a temperature above 66° F. The most active ferments are such substances as have already passed into the acetous state; hence vinegar, especially when it contains some yeasty particles, or is combined with porous and spongy bodies, so as to multiply its points of contact with the vinous liquor, is particularly powerful. Common yeast may also be employed for vinegar ferments, if it be imbued with a little vinegar, with leaven, crusts of bread soaked in vinegar, the stalks and husks of grapes, sawdust and shavings of beech or oak impregnated with vinegar, or the slimy sediment of vinegar casks called *mother;* all of which operate as ferments chiefly in consequence of the vinegar which they contain. The inside shavings of the staves of vinegar tuns act on the same principle.

The acetous fermentation may, moreover, go on along with the vinous in the same liquor, when this contains sugar as well as alcohol. Whilst the acidification of the alcohol is effected by the absorption of oxygen from the atmosphere, the sugar becomes alcohol with disengagement of carbonic acid, and then passes into vinegar. Since most liquors intended for making vinegar, such as wine, juices of fruits, ales, &c., contain still a little sugar, they disengage always a little carbonic acid. Besides spirits, some other substances, such as gum, the mucilage of plants, and starch paste, directly ferment into vinegar. Sugar also seems to be convertible into vinegar without any vinous change. The albuminous matter of potato juice, precipitated by vinegar, serves as a proper ferment for that purpose, when added in its moist state to weak sirup. 5. See PUTREFACTION.

Mr. William Black, in his treatise on Brewing, has, with much ingenuity and apparent truth, endeavored to show that the process of fermentation is strongly influenced by electricity, not only that of the atmosphere, as has been long known from the circumstance

of beer and wine becoming speedily sour after thunderstorms, but the voltaic, produced by electric combinations of metals in the fermenting tuns.   He therefore recommends these tuns to be made with as little metallic work as possible, and to be insulated from the floor of the brewhouse.   For the propriety of this advice he adduces some striking examples.   Wort which had become stationary in its fermentation, on being pumped out of square gyles imbedded in the floor, into casks placed upon wooden stillions, began immediately to work very well, and gained about 6 degrees of attenuation while throwing off its yeast.   From the stagnation of the process in the gyles, he had in the morning predicted an approaching thunderstorm, which accordingly supervened in the course of the evening.   In further support of his views he instances the fact, that, in dairies where the milk is put into porcelain vessels, and placed upon wooden shelves, it is seldom injured by lightning; but when contained in wooden or leaden vessels, and placed upon the ground, it almost invariably turns sour in thundery weather.   His general conclusion is, "that the preservation or destruction of beer depends upon electricity ; and the most certain mode of preservation is to insulate as much as possible, both the squares and all other utensils or vessels connected with the brewing or storing of beer."

Mr. Black further considers that unsoundness of worts is often the result of electricity excited between the mash tun and the copper.

Why is beer liable to get spoiled in thunder-storms, though apparently well insulated in glass bottles ?

I shall conclude this article with Mr. Black's description of the phenomena of beer fermentation.   In every regular process there are five distinct stages.   In the first we see a substance like cream forming all round the edges of the gyle tun; which extends towards the centre until the whole is creamed over, constituting the first change. Next a fine curl appears like cauliflower, which also spreads over the square surface, and according to the strength and appearance of this curl, the quality of the fermentation may be predicated.   This he calls the second stage.   What is technically called the *stomach* or vinous vapor now begins to be smelt, and continues to gain strength till the process is concluded.   From the vinous energy of this odor, and the progressive attenuation of the wort, the vigor of the fermentation may be inferred.   The experienced brewer is much guided in his operations by the peculiarity of this effluvium.   The third change is when the cauliflower or curling top rises to a fine rocky or light yeasty head; and when this falls down, the fourth stage has arrived.   Finally the head should rise to what is called close yeasty, having the appearance of yeast all over.   About this period the gas becomes so powerful as to puff up occasionally in little bells or bladders about the size of a walnut, which immediately break.   The bells should appear bright and clear. If they be opaque or whey colored, there is some unsoundness in the wort.   The great point is to add just so much yeast as to carry the fermentation completely through these five changes at the regular periods.

FERROCYANATE, or, more correctly, FERROCYANIDE.   (*Ferrocyanure*, Fr.; *Eisencyanid*, Germ.)   Several compounds of cyanogen and metals possess the property of uniting together into double cyanides; of which there are none so remarkable in this respect, as the protocyanide of iron.   This appears to be capable of combining with several simple cyanides, such as that of potassium, sodium, barium, strontium, calcium, and ammonium.   The only one of these double cyanides of any importance in manufactures is the first, which is described under its commercial name, PRUSSIATE OF POTASH.

FERROPRUSSIATES; another name for Ferrocyanides.

FIBRE, VEGETABLE, called also LIGNINE (*Ligneux*, Fr.; *Pflanzen-faserstoff*, Germ.), is the most abundant and general ingredient of plants, existing in all their parts, the root, the leaves, the stem, the flowers, and the fruit; amounting in the compact wood to 97 or 98 per cent.   It is obtained in a pure state by treating saw-dust successively with hot alcohol, water, dilute muriatic acid, and weak potash ley, which dissolve, first, the resinous; second, the extractive and saline matters; third, the carbonate and phosphate of lime; and, lastly, any residuary substances.   Ligneous fibres, such as saw-dust, powdered barks, straw, hemp, flax, linen, and cotton cloth, are convertible by the action of strong sulphuric acid into a gummy substance analogous to *dextrine*, and a sugar resembling that of the grape.

If we put into a glass mortar 24 parts, by weight, of dry old cordage, chopped small, and sprinkle over it 34 parts of sulphuric acid, by degrees, so as to avoid heating the mixture, while we constantly stir it; and if, in a quarter of an hour, we triturate the mass with a glass pestle, the fibres will disappear without the disengagement of gas. A tenacious mucilage will be produced, almost entirely soluble in water.   The gum being thus formed, may be separated from the acid by dilution with water, and addition of the requisite quantity of chalk; then straining the saturated liquid through linen cloth, concentrating it by evaporation, throwing down any remaining lime by oxalic

acid, filtering anew, and mixing the mucilage with alcohol in great excess, which will take up the free acid, and throw down the gum. From 24 parts of hemp fibres thus treated, fully 24 parts of a gummy mass may be obtained, containing, however, probably some water.

When, instead of saturating the diluted acid paste with chalk, we boil it for 10 hours, the gummy matter disappears, and is replaced by sugar, which may be purified without any difficulty, by saturation with chalk, filtration, and evaporation to the consistence of sirup. In 24 hours crystallization begins, and, in 2 or 3 days, a concrete mass of grape sugar is formed; which needs merely to be pressed strongly between old linen cloths doubled, and then crystallized a second time. If this sirup be treated with bone black, a brilliant white sugar will be procured. 20 parts of linen rags yield 23 of good sugar. *Braconnot.* Guerin got 87½ of dry sugar from 100 parts of rags, treated with 250 of sulphuric acid. See Wood.

FIBRINE (Eng. and Fr.; *Thierischer Faserstoff,* Germ.) constitutes the principal part of animal muscle; it exists in the chyle, the blood, and may be regarded as the most abundant constituent of animal bodies. It may be obtained in a pure state by agitating or beating new drawn blood with a bundle of twigs, when it will attach itself to them in long reddish filaments, which may be deprived of color by working them with the hands under a streamlet of cold water, and afterwards freed from any adhering grease by digestion in alcohol or ether.

Fibrine, thus obtained, is solid, white, flexible, slightly elastic, insipid, inodorous, denser than water, but containing four fifths of its weight of it, and without action on litmus. When dried, it becomes semi-transparent, yellowish, stiff, and brittle: water restores its softness and flexibility. 100 parts of fibrine consist of 53·36 carbon, 19·68 oxygen, 7·02 hydrogen, and 19·31 azote. As the basis of flesh, it is a very nutritious substance, and is essential to the sustenance of carnivorous animals.

FILE (*Lime,* Fr.; *Feile,* Germ.) is a well known steel instrument, having teeth upon the surface for cutting and abrading metal, ivory, wood, &c.

When the teeth of these instruments are formed by a straight sharp-edged chisel, extending across the surface, they are properly called files; but when by a sharp-pointed tool, in the form of a triangular pyramid, they are termed rasps. The former are used for all the metals, as well as ivory, bone, horn, and wood; the latter for wood and horn.

Files are divided into two varieties, from the form of their teeth. When the teeth are a series of sharp edges, raised by the flat chisel, appearing like parallel furrows, either at right angles to the length of the file, or in an oblique direction, they are termed *single cut.* But when these teeth are crossed by a second series of similar teeth, they are said to be *double cut.* The first are fitted for brass and copper, and are found to answer better when the teeth run in an oblique direction. The latter are suited for the harder metals, such as cast and wrought iron and steel. Such teeth present sharp angles to the substance, which penetrate it, while single cut files would slip over the surface of these metals. The double cut file is less fit for filing brass and copper, because its teeth would be very liable to become clogged with the filings.

Files are also called by different names according to their various degrees of fineness. Those of extreme roughness are called rough; the next to this is the bastard cut; the third is the second cut; the fourth, the smooth; and the finest of all, the dead smooth. The very heavy square files used for heavy smith-work, are sometimes a little coarser than the rough; they are known by the name of rubbers.

Files are also distinguished from their shape, as flat, half-round, three-square, four-square, and round. The first are sometimes of uniform breadth and thickness throughout, and sometimes tapering. The cross section is a parallelogram. The half-round is generally tapering, one side being flat, and the other rounded. The cross section is a segment of a circle, varying a little for different purposes, but seldom equal to a semi-circle. The three-square generally consists of three equal sides, being equilateral prisms, mostly tapering; those which are not tapering are used for sharpening the teeth of saws. The four-square has four equal sides, the section being a square. These files are generally thickest in the middle, as is the case with the smith's rubber. In the round file, the section is a circle, and the file generally conical.

The heavier and coarser kinds of files are made from the inferior marks of blistered steel. Those made from the Russian iron, known by the name of old sable, called from its mark CCND, are excellent. The steel made from the best Swedish iron, called hoop L or Dannemora, makes the finest Lancashire files, for watch and clock makers; a manufacture for which the house of Stubbs in Warrington is celebrated.

The steel intended for files is more highly converted than for other purposes, to give them proper hardness. It should however be recollected, that if the hardness be not accompanied with a certain degree of tenacity, the teeth of the file break, and do but little service.

Small files are mostly made of cast steel, which would be the best for all others, if

it were not for its higher price. It is much harder than the blistered steel, and from having been in the fluid state, is entirely free from those seams and loose parts so common to blistered steel, which is no sounder than as it comes from the iron forge before conversion.

The smith's rubbers are generally forged in the common smith's forge, from the converted bars, which are, for convenience, made square in the iron before they come into this country. The files of lesser size are made from bars or rods, drawn down from the blistered bars, and the cast ingots, and known by the name of tilted steel.

The file-maker's forge consists of large bellows, with coke as fuel. The anvil-block, particularly at Sheffield, is one large mass of mill stone girt. The anvil is of considerable size, set into and wedged fast into the stone; and has a projection at one end, with a hole to contain a sharp-edged tool for cutting the files from the rods. It also contains a deep groove for containing dies or bosses, for giving particular forms to the files.

The flat and square files are formed entirely by the hammer. One man holds the hot bar, and strikes with a small hammer. Another stands before the anvil with a two-handed hammer. The latter is generally very heavy, with a broad face for the large files. They both strike with such truth as to make the surface smooth and flat, without what is called hand-hammering. This arises from their great experience in the same kind of work. The expedition arising from the same cause is not less remarkable.

The half-round files are made in a boss fastened into the groove above mentioned. The steel being drawn out, is laid upon the rounded recess, and hammered till it fills the die.

The three-sided files are formed similarly in a boss, the recess of which consists of two sides, with the angle downwards. The steel is first drawn out square, and then placed in a boss with an angle downwards, so that the hammer forms one side, and the boss two. The round files are formed by a swage similar to those used by common smiths, but a little conical.

The file-cutter requires an anvil of a size greater or less, proportioned to the size of his files, with a face as even and flat as possible. The hammers weigh from one to five or six pounds. The chisels are a little broader than the file, sharpened to an angle of about 20 degrees. The length is just sufficient for them to be held fast between the finger and thumb, and so strong as not to bend with the strokes of the hammer, the intensity of which may be best conceived by the depth of the impression. The anvil is placed in the face of a strong wooden post, to which a wooden seat is attached, at a small distance below the level of the anvil's face. The file is first laid upon the bare anvil, one end projecting over the front, and the other over the back edge of the same. A leather strap now goes over each end of the file, and passes down upon each side of the block to the workman's feet, which, being put into the strap on each side, like a stirrup, holds the file firmly upon the anvil as it is cut. While the point of the file is cutting, the strap passes over one part of the file only, the point resting upon the anvil, and the tang upon a prop on the other side of the strap. When one side of the file is single cut, a fine file is run slightly over the teeth, to take away the roughness; when they are to be double cut, another set of teeth is cut, crossing the former nearly at right angles. The file is now finished upon one side, and it is evident that the cut side cannot be laid upon the bare anvil to cut the other. A flat piece of an alloy of lead and tin is interposed between the toothed surface and the anvil, while the other side is cut, which completely preserves the side already formed. Similar pieces of lead and tin, with angular and rounded grooves, are used for cutting triangular and half-round files.

Rasps are cut precisely in the same way, by using a triangular punch instead of a flat chisel. The great art in cutting a rasp is to place every new tooth as much as possible opposite to a vacancy.

Many abortive attempts have been made to cut the teeth of files by machinery. The following plan, for which a patent was obtained by Mr. William Shilton, of Birmingham, in April, 1833, is replete with ingenious mechanical resources, and deserves to succeed.

The blanks of steel for making the files and rasps, are held in a pair of clamps in connexion with a slide, and are moved forward at intervals under the head of the tilt hammer which carries the tool; the distance which the blank is to be advanced at every movement being dependant upon the required fineness or coarseness of the cut of the file, which movement is effected and regulated by a rack and pinion, actuated by a pall and ratchet wheel, or the movement may be produced by any other convenient means.

When the machine is employed for cutting or indenting the teeth of rasps, the cutting tool being pointed and only producing one tooth at a blow, the tilt hammer carrying the tool must be made to traverse at intervals across the width of the blank piece of steel

from one edge to the other and back again; the blank being advanced in length only when the hammer has produced the last cut or tooth toward either edge of the rasp.

In order to render this invention better understood, two views of the apparatus for producing the cross cut or teeth of the files are given.

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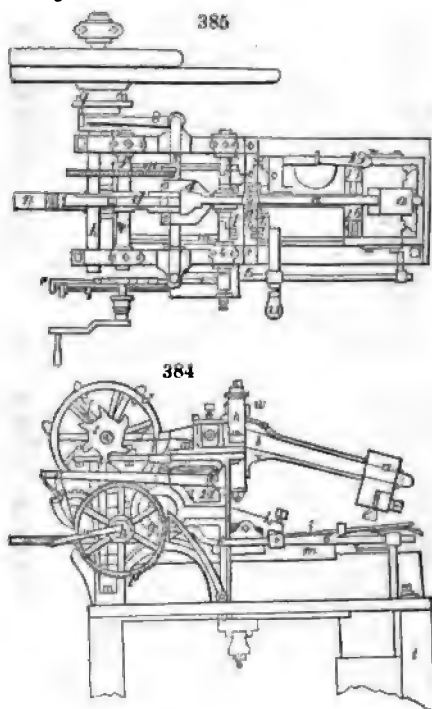
Fig. 384 is an elevation of the upper part of the file-cutting machine, as seen on one side; *fig.* 385 is a plan or horizontal view, as the machine appears on the top.

a, is the head of the tilt hammer placed in the end of the lever *b*, which is mounted on an axle *c*, turning in proper bearings in the frame work of the machine; *d*, is the tilt wheel mounted on another axle *s*, also turning in bearings on the frame work of the machine, and having any required number of projections or tappets upon it for depressing the tail or shorter end of the hammer or tilt lever *b*.

The tilt wheel *d*, receives its rotatory motion from the toothed wheel *f*, mounted upon the same axle, and it takes into gear with a pinion *g*, upon the main shaft *h*, which is actuated by a band passed from any first mover to the rigger on its end, or in any other convenient manner. The bed upon which the blank piece of steel bears is marked *i*. This bed is firmly supported upon masonry placed upon proper sleepers; *j*, is one of the blank pieces of steel under operation, and is shown secured in the pair of jaws or holding clamps *k*, mounted on centre pins in the slide *l*, *fig.* 385; which slide is held down by a spring and slide beneath, and is moved backwards and forwards in the machine upon the (v) edges *m*, *m*, of the frame, by means of the rack *n*, and its pinion; the latter being mounted upon the axle of the ratchet wheel *p*, and which ratchet wheel is made to turn at intervals by means of the pall *q*, upon the end of the lever *r*, *fig.* 385. This lever is depressed, after every cut has been effected upon the blank by means of the teeth or tappets of the wheel *s*, coming in contact with the inclined plane *t*, upon the lever *r*. The tappet wheel *s*, is mounted upon the end of the axle *c*, of the tilt wheel, and consequently revolves with it, and by depressing the lever *r*, every time that a tooth passes the inclined plane *t*, the click *q*, is made to drive the ratchet wheel *p*, and thereby the advancing movement of the blank is effected after each blow of the tilt hammer.

There is a strong spring *u*, attached to the upper side of the tilt hammer, its end being confined under an adjustable inclined plane *v*, mounted in the frame *w*, which inclined plane can be raised or lowered by its adjusting screws as required, to produce more or less tension of the spring.

A similar spring is placed on the under side of the tilt hammer, to raise and sustain the cutter or tool clear of the bed after every blow, and in conjunction with safety holders or catchers, to counteract any vibration or tendency the spring *u* may have to cause the hammer to reiterate the blow.

The end of the lower spring acts on an inclined plane, mounted in the frame *w*, which has an adjusting screw similar to *v*, to regulate the tension of the spring.

In case the under spring should raise, that is, return the hammer, with sufficient force or velocity to cause the top spring *u*, to reiterate the blow, the ends of the safety holders or catchers are made to move under and catch the tail of the lever *b*, immediately on its being raised by the under springs, which is effected by the following means :—The holders are mounted upon a plate or carriage 1, *fig.* 384, which turns upon a small pin or axle mounted in the ears of a cross bar; the upper ends of the holders are kept inclined towards the tail of the tilt hammer by means of a spring fixed to the cross bar, and which acts upon one end of the plate or carriage 1.

In order that the holders may be removed out of the way of the tail of the hammer *b*, when the tilt wheel is about to effect a blow, the tooth of the tilt wheel which last acted upon the hammer comes in contact with an inclined plane fixed on the plate or carriage 1, and by depressing that end of the plate, causes the upper ends of the holders to be withdrawn from under the tail of the hammer *b*. The tilt wheel continuing to revolve, the next tooth advances, and depresses the tail of the hammer, but before it leaves the tail of the hammer, the tooth last in operation will have quitted the inclined plane and allowed the spring to return the holders into their former position. After the tooth has escaped from the tail of *b*, the hammer will immediately descend and effect the blow or cut on the blank, and as the tail of the hammer rises, it will come in contact with the inclined planes at the upper ends of the holders, and force them backwards; and as soon as the tail of the hammer has passed the top of the holders, the spring will immediately force the holders forward under the tail of the hammer, and prevent the hammer rising again until the next tooth of the tilt wheel is about to depress the end of the hammer, when the same movements of the parts will be repeated, and the machine will continue in operation until a sufficient length of the blank of steel (progressively advanced under the hammer) has been operated upon, when it will be thrown out of gear by the following means:—

Upon the sliding bar 6 there is placed an adjustable stop, against which the foremost end of the slide *l l, fig.* 385, comes in contact as it is moved forward by the rack *n*, and its pinion. The sliding bar 6 is connected at its left end to the bent lever 8, the other end of this lever being formed into a forked arm, which embraces a clutch upon the main shaft, and as the slide *l* continues to advance, it will come in contact with a stop; and when it has brought a sufficient length of the blank pieces of steel under the operation of the cutting tool, the slide *l*, in its progress, will have moved that stop and the bar 6 forward, and that bar, by means of the bent lever 8, will withdraw the clutch on the main shaft, from locking into the boss of the fly-wheel, and consequently stop the further progress of the machine; the rigger and fly-wheel turning loosely upon the main shaft.

The cut file can now be removed from out of the clamps, and reversed to cut the other side, or another blank piece put in its place; and after throwing back the pall *q* of the ratchet wheel *p*, the slide *l*, and with it the fresh blank may be moved back into the machine by turning the winch handle, on the axle of the ratchet wheel *p*, the reverse way, which will turn the pinion backwards, and draw back the rack *n*, without affecting any other parts of the machine; and on moving back the bar 6, by the handle 11, placed on the stop, the clutches will be thrown into gear again, and the machine proceed to cut the next blank.

When the blanks have been thus cut on one side, and are reversed in the machine to form the teeth upon the other side, there should be a piece of lead placed between the blank and the bed to protect the fresh cut teeth.

It will be seen that the position of the stop upon the bar 6 will determine the length or extent of the blank piece of steel which shall be cut or operated upon; and in order that the progressive movement of the blanks under the cutting tool may be made to suit different degrees of fineness or coarseness of the teeth (that is, the distance between the cuts), there is an adjusting screw upon the lever *r*, the head of which screw stops against the under side of an ear projecting from the frame-work, and thereby determines the extent of the motion of the lever *r*, when depressed by the tappets of the wheel *s*, acting upon the inclined plane *t*, consequently determining the number of teeth the ratchet wheel *p* shall be moved round by the pall *q*; and hence the extent of motion communicated by the rack and pinion to the slide *l*, and the blank *j*, which regulates the distance that the teeth of the file are apart, and the lever *r* is forced upwards by a spring pressing against its under side.

It will be perceived that the velocity of the descent of the hammer, and consequently the force of the blow, may be regulated by raising or lowering the inclined plane *v* of the spring *u ;* and in order to accommodate the bed upon which the blanks rest to the different inclinations they may be placed at, that part of the bed is formed of a semi-globular piece of hardened steel, which fits loosely into a similar concavity in the bed *r*, and is therefore capable of adjusting itself so that the blanks shall be properly presented to the cutting tool, and receive the blow or cut in an equal and even manner; or the piece of steel may be of a conical shape, and fit loosely in a similar shaped concavity.

There are guides, 16, placed on the top of the bed *i*, for the purpose of keeping the blanks in their proper position towards the cutting tool, and these can be regulated to suit blanks of any width, by turning the right and left handed screw 17. There is also another adjustable stop on the jaws or clamps *k*, which serves as a guide when placing the blanks within the jaws; and 19 is a handle or lever for raising the clamps when required, which has a weight suspended from it for the purpose of keeping down the blanks with sufficient pressure upon the bed.

The cutting tool in the face of the hammer, can be placed at any required angle or

inclination with the blank, it being secured in the head of the hammer by clamps and screws. In cutting fine files a screw is employed in preference to the rack and pinion, for advancing the slide *l*, and the blank piece of steel in the machine.

Hardening of files.—This is the last and most important part of file making. Whatever may be the quality of the steel, or however excellent the workmanship, if it is not well hardened all the labor is lost.

Three things are strictly to be observed in hardening; first, to prepare the file on the surface, so as to prevent it from being oxydated by the atmosphere when the file is red hot, which effect would not only take off the sharpness of the tooth, but render the whole surface so rough that the file would, in a little time, become clogged with the substance it had to work. Secondly, the heat ought to be very uniformly red throughout, and the water in which it is quenched, fresh and cold, for the purpose of giving it the proper degree of hardness. Lastly, the manner of immersion is of great importance, to prevent the files from warping, which in long thin files is very difficult.

The first object is accomplished by laying a substance upon the file, which, when it fuses, forms, as it were, a varnish upon the surface, defending the metal from the action of the oxygen of the air. Formerly the process consisted in first coating the surface of the file with ale grounds, and then covering it over with pulverized common salt (muriate of soda). After this coating became dry, the files were heated red hot, and hardened; after this, the surface was lightly brushed over with the dust of cokes, when it appeared white and metallic, as if it had not been heated. This process has lately been improved, at least so far as relates to the economy of the salt, which, from the quantity used, and the increased thickness, had become a serious object. Those who use the improved method are now consuming about one fourth the quantity of salt used in the old method. The process consists in dissolving the salt in water to saturation, which is about three pounds to the gallon, and stiffening it with ale grounds, or with the cheapest kind of flour, such as that of beans, to about the consistence of thick cream. The files require to be dipped only into this substance, and immediately heated and hardened. The grounds or the flour are of no other use than to give the mass consistence, and by that means to allow a larger quantity of salt to be laid upon the surface. In this method the salt forms immediately a firm coating. As soon as the water is evaporated, the whole of it becomes fused upon the file. In the old method the dry salt was so loosely attached to the file, that the greatest part of it was rubbed off into the fire, and was sublimed up the chimney, without producing any effect.

The carbonaceous matter of the ale grounds is supposed to have some effect in giving hardness to the file, by combining with the steel, and rendering it more highly carbonated. It will be found, however, upon experiment, that vegetable carbon does not combine with iron, with sufficient facility to produce any effect, in the short space of time a file is heating for the purpose of hardening. Some file makers are in the habit of using the coal of burnt leather, which doubtless produces some effect; but the carbon is generally so ill prepared for the purpose, and the time of its operation so short, as to render the result inconsiderable. Animal carbon, when properly prepared and mixed with the above hardening composition, is capable of giving hardness to the surface even of an iron file.

This carbonaceous matter may be readily obtained from any of the soft parts of animals, or from blood. For this purpose, however, the refuse of shoemakers and curriers is the most convenient. After the volatile parts have been distilled over, from an iron still, a bright shining coal is left behind, which, when reduced to powder, is fit to mix with the salt. Let about equal parts, by bulk, of this powder, and muriate of soda be ground together, and brought to the consistence of cream, by the addition of water. Or mix the powdered carbon with a saturated solution of the salt, till it become of the above consistence. Files which are intended to be very hard should be covered with this composition previous to hardening. All files intended to file iron or steel, particularly saw files, should be hardened with the aid of this mixture, in preference to that with the flour or grounds. Indeed, it is probable that the carbonaceous powder might be used by itself, in point of economy, since the ammonia or hartshorn, obtained by distillation, would be of such value as to render the coal of no expense. By means of this method the files made of iron, which, in itself, is unsusceptible of hardening, acquire a superficial hardness sufficient for any file whatever. Such files may, at the same time, be bent into any form; and, in consequence, are particularly useful for sculptors and die-sinkers.

The next point to be considered is the best method of heating the file for hardening. For this purpose a fire, similar to the common smith's fire, is generally employed. The file is held in a pair of tongs by the tang, and introduced into the fire, consisting of very small cokes, pushing it more or less into the fire for the purpose of heating it regularly. It must frequently be withdrawn with the view of observing that it is not too hot in any part. When it is uniformly heated, from the tang to the point, of a

or, it is fit to quench in the water. At present an oven formed of fire-
for the larger files, into which the blast of the bellows is directed, being
:nd, for the purpose of introducing the files and the fuel. Near to the top
:e placed two cross bars, on which a few files are placed, to be partially
he hardening of heavy files this contrivance affords a considerable sav-
of time, while it permits them also to be more uniformly and thoroughly

e is properly heated for the purpose of hardening, in order to produce the
)le hardness, it should be cooled as soon as possible. The most common
eting this is by quenching it in the coldest water. Some file-makers have
.bit of putting different substances in their water, with a view to increase
property. The addition of sulphuric acid to the water was long held a
the hardening of saw files. After all, however, it will be found that clear
free from animal and vegetable matter, and as cold as possible, is the best
hardening files of every description.
ig the files in water, some caution must be observed. All files, except the
)uld be immersed perpendicularly, as quickly as possible, so that the upper
cool. This management prevents the file from warping. The half-round
lenched in the same steady manner; but, at the same time that it is kept
to the surface of the water, it must be moved a little horizontally, in the
e round side, otherwise it will become crooked backwards.
es are hardened, they are brushed over with water and powdered cokes,
ice becomes perfectly clean and metallic. They ought also to be washed
three clean waters, for the purpose of carrying off all the salt, which, if
iain, will be liable to rust the file. They should moreover be dipped into
d rapidly dried before the fire, after being oiled with olive oil, containing a
·pentine, while still warm. They are then finished.
E (*Filigrane*, Fr.; *Filigran*, or *Feine Drahtgeflecht*, Germ.) is, as the last
:presses it, intertwisted fine wire, used for ornamenting gold and silver
: wire is seldom drawn round, but generally flat or angular, and soldered
er solder with borax and the blowpipe. The Italian word, *filigrana*, is
f *filum* and *granum*, or granular net-work; because the Italians, who first
i style of work, placed small beads upon it.
ON (Eng. and Fr.; *Filtriren*, Germ.) is a process, purely mechanical, for
quid from the undissolved particles floating in it, which liquid may be either
., as in vegetable infusions, or of no use, as the washings of mineral pre-
ie filtering substance may consist of any porous matter in a solid, folia-
ilent form; as porous earthenware, unsized paper, cloth of many kinds, or
hite blotting paper sold by the stationers, answers extremely well for filters
periments, provided it be previously washed with dilute muriatic acid, to
ime and iron that are generally present in it. Filter papers are first cut
en folded twice diagonally into the shape of a cornet, having the angular
off. Or the piece of paper being cut into a circle, may be folded fan-like
e, with the folds placed exteriorly, and turned out sharp by the pressure of
thumb, to keep intervals between the paper and the funnel into which it
vor the percolation. The diameter of the funnel should be about three
height, measured from the neck to the edge. If it be more divergent, the
:oo small for the ready efflux of the fluid. A filter covered with the sedi-
conveniently washed by spouting water upon it with a little syringe. A
hair paint brush is much employed for collecting and turning over the con-
ioft state. Agitation or vibration is of singular efficacy in quickening per-
displaces the particles of the moistened powders, and opens up the pores
:ome closed. Instead of a funnel, a cylindrical vessel may be employed,
·orated bottom covered with a disc of filtering powder folded up at the
Je tight there by a wire ring. Linen or calico is used for weak alkaline
lannels, twilled woollen cloth, or felt-stuff, for weak acid ones. These
often made conical like a fool's cap, and have their mouths supported by a
allic hoop. Cotton wool put loose into the neck of a funnel answers well
s upon the small scale. In the large way, oil is filtered in conical woollen
ask with many conical tubes in its bottom, filled with tow or cotton wool.
and alkaline liquors must be filtered through a layer of pounded glass,
iand, or bruised charcoal. The alcarrhazas are a porous biscuit of stone
Spain, which are convenient for filtering water, as also the porous filtering
·iffe, largely imported into England at one time, but now superseded in a
eby the artificial filters patented under many forms, consisting essentially
ravel, sand, and charcoal powder.
ient to render the filter self-acting, by accommodating the supply of liquid

to the rate of percolation, so that the pressure upon the porous surface may be always equally great. Upon the small scale, the lamp-fountain or bird's-glass form, so generally used for lamps, will be found to answer.

Fig. 386 represents a glass bottle, A, partly filled with the fluid to be filtered, supported in the ring of a chemical stand, and having its mouth inverted into the same liquor in the filter funnel. It is obvious that whenever this liquor by filtration falls below the lip of the bottle, air will enter into it, let down a fresh supply to feed the filter, and keep the funnel regularly charged. If larger quantities are to be operated upon, the following apparatus may be employed. *Fig.* 387, A B, is a metallic vessel which may be made air-tight; c is the under pipe, provided with a stopcock, R, for letting down the liquor into the filter *a b*. The upper pipe *t*, through which the fluid is poured by means of the funnel E, has also a stopcock which opens or shuts, at the same time, the small side tube *s t*, through which, during the entrance of the fluid, the air is let off from the receiver. A glass tube, g, shows the level of the liquor in the body of the apparatus. In using it, the cock R must be first closed, and the cock *s* must be opened to fill the receiver. Then the filter is set a going, by re-opening the cock R, so as to keep the fluid in the filter upon a level with the opening of the tube c. Both these pieces of apparatus are essentially the same.
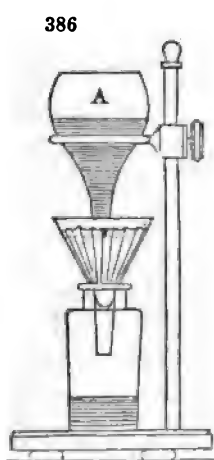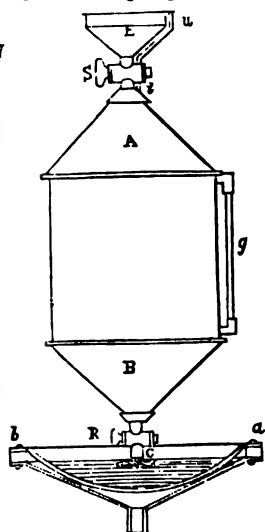
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In many manufactures, self-acting filters are fed by the plumber's common contrivance of a ball-cock, in which the sinking and rising of the ball, within certain limits, serves to open or shut off the supply of liquor, as it may be required or not. Dumont has adopted this expedient for his system of filtering sirup through a stratum of granularly ground animal charcoal or bone-black. *Fig.* 388 is a front view of this apparatus with 4 filters, c; and *fig.* 389 is a cross section. The framework B supports the cistern A, in which the sirup is contained. From it the liquor flows through the stopcock

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ıd the connexion-tube a, into the common pipe c, which communicates, by the short
ıch tubes e, with each of the four filters. The end of the branch tube, which is inside
he filter tub, is provided with a stop-cock d f, whose opening, and thereby the efflux
ıe liquor from the cistern through the tube a, is regulated by means of the float-ball g.
n the brickwork D the filter tub stands, furnished at h with a false bottom of zinc or
ıer pierced with fine holes; besides which, higher up at i there is another such plate
ıetal furnished with a strong handle k, by which it may be removed, when the bone
k needs to be changed. In the intervening space l, the granular coal is placed. o is
cover of the filter tub, with a handle also for lifting it. One portion of it may be rais-
y a hinge, when it is desired to inspect the progress of the filtration within. m m is a
ıer vertical tube, forming a communication between the bottom part h, and the upper
ion of the filter, to admit of the easy escape of the air from that space, and from among
bone black as the sirup descends; otherwise the filtration could not go on. p is the
cock through which the fluid collected in the space under h, is let off from time to time
the common pipe q, fig. 388. r is a trickling channel or groove lying parallel to the
q, and in which, by means of a tube s, inserted at pleasure, the sirup is drawn off
ıse of its flowing in a turbid state, when it must be returned over the surface of the
coal.

he celerity with which any fluid passes through the filter depends, 1. upon the porosi-
f the filtering substance; 2. upon the pressure exercised upon it; and 3. upon the ex-
of the filtering surface. Fine powders in a liquor somewhat glutinous, or closely
pacted, admit of much slower filtration than those which are coarse and free; and the
ıer ought, therefore, to be spread in a thinner stratum and over a more extensive sur-
than the latter, for equal effect; a principle well exemplified in the working of Du-
l's apparatus, just described.

many cases filtration may be accelerated by the increase of hydrostatic or pneu-
c pressure. This happens when we close the top of a filtering cylinder, and con-
it by a pipe with a cistern of fluid placed upon a higher level. The pressure of the
may be rendered operative also either by withdrawing it partially from a close
el, into which the bottom of the filter enters, or by increasing its density over the
ıf the liquor to be filtered. Either the air pump or steam may be employed to
te a partial void in the receiver beneath the filter. In like manner, a forcing pump
eam may be employed to exert pressure upon the surface of the filtering liquor. A
non syphon may, on the same principle, be made a good pressure filter, by making
ıpper leg trumpet-shaped, covering the orifice with filter paper or cloth, and filling
whole with liquor, the lower leg being of such length so as to create considerable
ıure by the difference of hydrostatic level. This apparatus is very convenient either
he small or great scale, for filtering off a clear fluid from a light muddy sediment.
pressure of the atmosphere may be elegantly applied to common filters, by the appa-
ı represented in fig. 390, which is merely a funnel enclosed within a gasometer. The
A n bears an annular hollow vessel a b, filled with water, in which receiver the cyl-
cal gasometer d, e, f, i, is immersed. The filter funnel is secured at its upper
to the inner surface of the annular vessel a b. In consequence of the pressure of
gasometer regulated by the weight g, upon the air enclosed within it, the liquid is
lly pressed, and the water in the annular space rises to a corresponding height on the
r surface of the gasometer, as shown in the figure. Were the apparatus made of
ı iron, the annular space might be charged with mercury.

general, relatively to the application of pressure to filters, it may be remarked,
it cannot be pushed very far, without the chance of deranging the apparatus, or
ering the filtered liquor muddy. The enlargement of the surface is, generally
king, the safest and most efficacious plan of increasing the rapidity of filtration,
cially for liquids of a glutinous nature. This expedient is well illustrated in the creased
filter now in use in most of the sugar refineries of London. See SUGAR.

. many cases it is convenient so to construct the filtering apparatus, as that the
d shall not descend, but mount by hydrostatic pressure. This method has two
ıntages: 1. that without much expensive apparatus, any desired degree of hydro-
c pressure may be given, as also that the liquid may be forced up through several fil-
ıg surfaces placed alongside of each other; 2. that the object of filtering, which is to
rate the particles floating in the fluid without disturbing the sediment, may be per-
y attained, and thus very foul liquids be cleared without greatly soiling the filtering
ıce.

ıch a construction is peculiarly applicable to the purification of water, either alone,
ımbined with the downwards plan of filtration. Of the former variety an example
ıown in fig. 391. The wooden or zinc conical vessel is provided with two per-
ıed bottoms or sieves e e, betwixt which the filtering substance is packed. Over
for the formation of the space h h, there is a third shelf, with a hole in its middle,
ugh which the tube d b is passed, so as to be water tight. This places the upper

open part of the apparatus in communication with the lowest space a. From the compartment $h\,h$ a small air tube l runs upwards. The filtering substance consists at bottom of pebbles, in the middle of gravel, and at the top of fine sand, which may be mixed with coarsely ground bone black, or covered with a layer of the same. The water to be filtered being poured into the cistern at top, fills through the tube $b\,d$ the inferior compartment a, from which the hydrostatic pressure forces the water upward through the perforated shelf, and the filtering materials. The pure water collects in the space $h\,h$, while the air escapes by the small tube l, as the liquid enters. The stopcock i serves to draw off the filtered water. As the motion of the fluid in the filter is slow, the particles suspended in it have time to subside by their own gravity; hence there collects over the upper shelf at d, as well as over the under one at a, a precipitate or deposite which may be washed out of the latter cavity by means of the stopcock m.

As an example of an upwards and downwards filter, *fig.* 392 may be exhibited. $A\,B\,C\,D$ is a wooden or metallic cistern furnished with the perforated shelf $c\,d$ near its under part, upon which a vertical partition is fixed through the axis of the vessel. A semicircular perforated shelf is placed at a, and a second similar one at b. These horizontal shelves rest upon brackets in the sides of the cisterns, so that they may be readily lifted out. The space a is filled with coarse sand, J with moderately fine, and H with very fine. The foul water is poured into the chamber E, and presses through $G\,J\,H$ and into the space F; whence it may be drawn by the stopcock f.
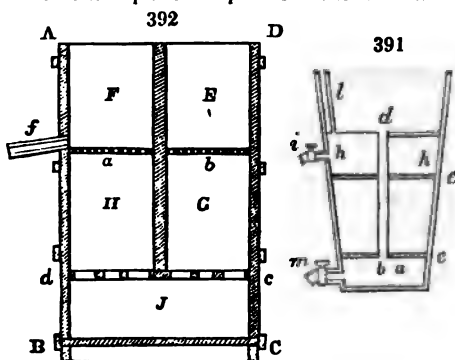
392

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Fig. 393 represents in section a filtering apparatus consisting of two concentric chambers; the interior being destined for downwards filtration, and the exterior for upwards. Within the larger cistern A, a smaller one B is placed concentrically, with its under part, and is left open from distance to distance, to make a communication between the interior cavity and the exterior annular space. These cavities are filled to the marked height with sand and gravel. The inner cylindrical space has fine sand below, then sharper sand with granular charcoal, next coarse sand, and lastly gravel. The annular space has in like manner fine sand below. The foul water is introduced by the pipe E, the orifice at whose end is acted upon by a ball-cock with its lever a; whereby the water is kept always at the same level in the inner vessel. The water sinks through the sand strata of the middle vessel, passes outwards at its bottom into the annular space, thence up through the sand in it, and collecting above it, is let off by the stopcock on the pipe b. When a muddy deposite forms after some time, it may be easily cleared out. The cord e, running over the pulleys $f\,f$, being drawn tight, the ball lever will shut up the valve. The stopcock d made fast to the conducting tube E must then be opened, so that the water now overflows into the annular space at A; the tube c, in communication with the inner space B, being opened by taking out the stopper h. The water thereby percolates through the sand strata in the reverse direction of its usual course, so as to clear away the impurities in the space B, and to discharge them by the pipe $c\,h$. An apparatus of this kind of moderate size is capable of filtering a great body of water. It should be constructed for that purpose of masonry; but upon a small scale it may be made of stone-ware.

393

A convenient apparatus for filtering oil upwards is represented in *fig.* 394. g is an oil cask, in which the impure parts of the oil have accumulated over the bottom. Immediately above this, a pipe a is let in, which communicates with an elevated water cistern

ie filter (placed on the lid of the cask), furnished with two perforated shelves, and another at *d*; which divide the interior of the filter into three compartments. Into the lower space immediately over the shelf *e*, the tube *b*, furnished with a stopcok, enters, to establish a communication with the cask; the middle cavity *e* is filled with coarsely ground charcoal or other filtering materials; and the upper one has an eduction pipe, *l*. When the stopcocks of the tubes *a* and *b* are opened, the water passes from the cistern into the oil cask, occupies from its density always the lowest place, and presses the oil upwards, without mixing the two liquids; whereby first the upper and purer portion of the oil is forced through the tube *b* into the filter, and thence out through the pipe *l*. When the fouler oil follows, it deposites its impurities in the space under the partition *c*, which may from time to time be drawn off through the stopcock *k*, while the purer oil is pressed upwards through the filter. In this way the different strata of oil in the cask may be filtered off in succession, and kept separate, if found necessary, for sale or use, without run-

394

:isk of mixing up the muddy matter with what is clear. According to the the water cistern *n*, will be the pressure, and, of course, the filtering force. filter gets choked with dirt, it may be easily recharged with fresh materials. .ng caustic alkaline leys through linen or quartz, it is proper to exclude the :t of air; which is done by enclosing the upper vessel, and attaching a pipe of ition between its cover and the shoulder of the lower vessel or recipient of the roportion as these flow down, they will displace their bulk of air, and drive top of the upper vessel above the foul leys.
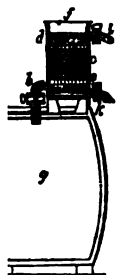
odifications of the above described apparatus are now on sale in this country; ly the neatest, most economical, and effective means of transforming the water ant muddy pool into that of a crystalline fountain, is afforded by the Royal ters of George Robins.

,RMS, MANUFACTURE OF. This art is divided into two branches, that of the id of the wooden work. The first includes the barrel, the lock, and the mount- ı the bayonet and ramrod, with military arms. The second comprises the stock, ling pieces, likewise the ramrod.

Barrel. Its interior is called the bore; its diameter, the calibre; the back -eech; the front end, the muzzle; and the closing of the back end, the breech ;. The barrel is generally made of iron. Most military muskets and low- is are fashioned out of a long slip of sheet-iron, folded together edgewise kewer into a cylinder, are then lapped over at the seam, and welded at a .. The most ductile and tenacious soft iron, free from all blemishes, must be r this slip. It is frequently welded at the common forge, but a proper air- nswers better, not being so apt to burn it. It should be covered with ashes . The shape of the bore is given by hammering the cylinder upon a steel ı a groove of the anvil. Six inches of the barrel at either end are left open ; the breech and the muzzle by a subsequent welding operation; the extrem- to the fire being stopped with clay, to prevent the introduction of cinders. length of two inches there are from two to three welding operations, divided ating high and low heats; the latter being intended to correct the defects of :. The breech and muzzle are not welded upon the mandril, but upon the ie anvil; the breech being thicker in the metal, is more highly heated, and is ewhat wider to save labor to the borer. The barrel is finally hammered in : of the anvil without the mandril, during which process it receives a heat ı minutes. In welding, the barrel extends about one third in length; and ·ts, is eventually left from 3 to 3½ feet long; but for cavalry pistols, only 9

st iron plates for gun-barrels are those made of *stub* iron, that is, of old : nails welded together, and forged into thin bars, or rather narrow ribands. ne *damascus* barrels were much in vogue; they were fashioned either as above from plates made of bars of iron and steel laid parallel, and welded together, bands of the same damascus stuff coiled into a cylinder at a red heat, and then gether at the seams. The best modern barrels for fowling pieces are con- f stub-nail iron in this manner. The slip or fillet is only half an inch broad, nes less, and is left thicker at the end which is to form the breech, and thinner l which is to form the muzzle, than in the intermediate portion. This fillet lerately heated to increase its pliancy, is then lapped round the mandril in a ection till a proper length of cylinder is formed; the edges being made to . little in order to give them a better hold in the welding process. The coil

being taken off the mandril and again heated, is struck down vertically with its muzzle end upon the anvil, whereby the spiral junctions are made closer and more uniform. It is now welded at several successive heats, hammered by horizontal strokes, called jumping, and brought into proper shape on the mandril. The finer barrels are made of still narrower stub-iron slips, whence they get the name of wire twist. On the Continent, barrels are made of steel wire, welded together lengthwise, then coiled spirally into a cylinder. Barrels that are to be rifled require to be made of thicker iron, and that of the very best quality, for they would be spoiled by the least portion of scale upon their inside. Soldiers' muskets are thickened a little at the muzzle, to give a stout holding to the bayonet.

The barrels thus made are annealed with a gentle heat in a proper furnace, and slowly cooled. They are now ready for the borer, which is an oblong square bit of steel, pressed in its rotation against the barrel, by a slip of wood applied to one of its flat sides, and held in its place by a ring of metal. The boring bench works horizontally, and has a very shaky appearance, in respect at least of the bit. In some cases, however, it has been attempted to work the barrels and bits at an inclination to the horizon of 30°, in order to facilitate the discharge of the borings. The barrel is held in a slot by only one point, to allow it to humor the movements of the borer, which

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396
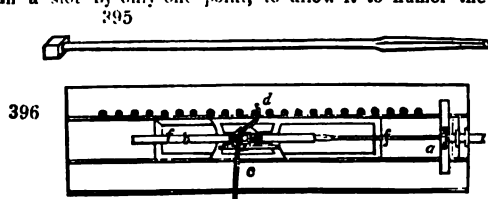
would otherwise be infallibly broken. The bit, as represented in *fig.* 395, has merely its square head inserted into a clamp-chuck of the lathe, and plays freely through the rest of its length.

Fig. 396 represents in plan the *boring bench* for musket barrels; *f f* is the sledge or carriage frame in which the barrel is supported; *a* is the revolving chuck of the lathe, into which the square end of the bit, *fig.* 395, is inserted; *b* is the barrel, clamped at its middle to the carriage, and capable of being pressed onwards against the tapering bit of the borer, by the bent lever *c*, worked by the left hand of the operative against fulcrum knobs at *d*, which stand about two inches asunder. Whenever the barrel has been thereby advanced a certain space to the right, the bent end of the lever is shifted against another knob or pin. The borer appears to a stranger to be a very awkward and unsteady mechanism, but its perpetual vibrations do not affect the accuracy of the bore. The opening broach may be of a square or pentagonal form, and either gradually tapered from its thickest part, or of uniform diameter till within two inches of the end, whence it is suddenly tapered to a point.

A series of bits may be used for boring a barrel, beginning with the smallest and ending with the largest. But this multiplication of tools becomes unnecessary, by laying against the cutting part of the bit slips of wood, called spales, of gradually increasing thickness, so that the edge is pressed by them progressively further from the axis. The bore is next polished. This is done by a bit with a very smooth edge, which is mounted as above, with a wedge of wood besmeared with a mixture of oil and emery. The inside is finished by working a cylindrical steel file quickly backwards and forwards within it, while it is revolving slowly.

In boring, the bit must be well oiled or greased, and the barrel must be kept cool by letting water trickle on it; for the bit, revolving at the rate of 120 or 140 times a minute, generates a great deal of heat. If a flaw be detected in the barrel during the boring, that part is hammered in, and then the bit is employed to turn it out.

Many sportsmen are of opinion that a barrel with a bore somewhat narrowed towards the muzzle serves to keep shot better together; and that roughening its inside with pounded glass has a good effect, with the same view. For this purpose, also, fine spiral lines have been made in their interior surface. The justness of its calibre is tried by means of a truly turned cylinder of steel, 3 or 4 inches long, which ought to move without friction, but with uniform contact from end to end of the barrel. Whatever irregularities appear must be immediately removed.

The outer surface of the barrel is commonly polished upon a dry grindstone, but it is better finished, and less dangerously to the workman, at a turning lathe with a slide rest. If a stone be used, it should be made to revolve at the mouth of a tunnel of some kind, into which there is a good draught to carry off the ferruginous particles. A piece of moist cloth or leather should be suspended before the orifice.

Rifle barrels have parallel grooves of a square or angular form cut within them, each groove being drawn in succession. These grooves run spirally, and form each an aliquot part of a revolution from the chamber to the muzzle. Rifles should not be too deeply indented; only so much as to prevent the ball turning round within the barrel,

ires should be truly parallel, that the ball may glide along with a regular
infra.

sian gun-makers, who are reckoned very expert, draw out the iron for the
hand forges, in fillets only one ninth of an inch thick, one inch and a half
four feet long. Twenty-five of these ribands are laid upon each other, between
ones of double thickness, and the bundle, weighing 60 pounds, bound with
> places, serves to make two ·barrels. The thicker plates are intended to
thinner from the violence of the fire in the numerous successive heats neces-
iplete the welding, and to form the bundle into a bar two thirds of an inch
ialf an inch thick; the direction of the individual plates relatively to the
ing preserved. This bar, folded flat upon itself, is again wrought at the
is only half an inch broad, and a quarter of an inch thick, while the plates of
re ribands are now set perpendicular to the breadth of the narrow fillet; the
rhich must be 15 or 16 feet French (16 or 17 English), to form a fowling
28 to 30 inches long. This fillet, heated to a cherry red in successive
coiled into as close a spiral as possible, upon a mandril about two fifths
in diameter. The mandril has at one end a stout head for drawing it out,
f the hammer and the grooves of the anvil, previous to every heating. The
performed upon a mandril introduced after each heat; the middle of the
ʒ first worked, while the fillets are forced back against each other, along the
the mandril, to secure their perfect union. The original plates having in the
f the ultimate long riband become very thin, appear upon the surface of the
threads of a fine screw, with blackish tints to mark the junctions. In making
rrelled gun, the two are formed from the same bundle of slips, the coils of the
l fillet being turned to the right hand, and those of the other to the left.

nascus barrels forged as above described, from a bundle of steel and iron
alternately together, are twisted at the forge several times, then coiled and
usual. Fifteen Parisian workmen concur in one operation : six at the forge;
boring mill; seven at filing, turning, and adjusting; yet all together make
irs of barrels per week, which are sold at from 100 to 300 francs the pair, ready
into the stock.

·ching is of three kinds : the common; the chamber, plug, or mortar, *fig.* 397;
and the patent, *fig.* 398. The common was formerly used for soldiers' muskets and inferior pieces. The second is a trifling improvement upon it. In the patent breeching, the screws do not interfere with the touch-hole, and the ignition is quicker in the main chamber.
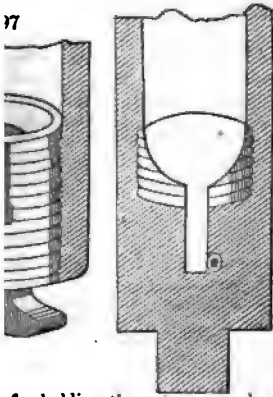
The only locks which it is worth while to describe are those upon the percussion principle, as flint locks will certainly soon cease to be employed even in military muskets. Forsyth's lock (*fig.* 399) was an ingenious contrivance. It has a magazine *a*, for containing the detonating powder, which revolves round a roller *b*, whose end is screwed into the breech of the barrel. The priming powder passes through a small hole in the roller, which leads to a channel in communication with the chamber of the gun.

for holding the priming is placed immediately over the little hole in the roller.
steel punch *c*, in the magazine, whose under end stands above the pan, ready
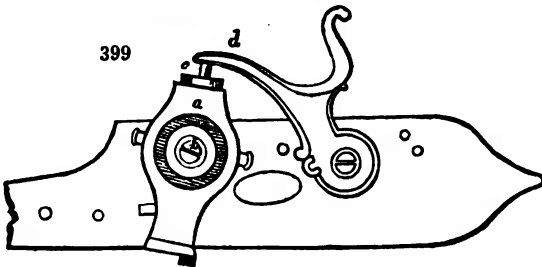
to ignite the priming when struck upon the top by the cock *d*, whenever the trigger is drawn. The punch immediately after being driven down into the pan is raised by the action of a spiral spring. For each explosion, the magazine must be turned so far round as to let fall a portion of the percussion powder into the pan; after which it is turned back, and the steel punch recovers its proper position for striking another blow into the pan.

The invention of the copper percussion cap was another great improvement upon the detonating plan. *Fig.* 400 represents the ordinary percussion lock, which is happily divested of three awkward projections upon the flint lock, namely, the hammer, hammer spring, and the pan. Nothing now appears upon the plate of the lock, but the cock or striking hammer, which inflicts the proper blow upon the percussion cap. It is concave, with a small metallic ring or border, called a shield or fence, for the purpose of enclosing the cap, as it were, and preventing its splinters doing injury to the sportsman, as also protecting against the line of flame which may issue from the touch-hole in the cap nipple. This is screwed into the patent breech, and is perforated with a small hole.

400
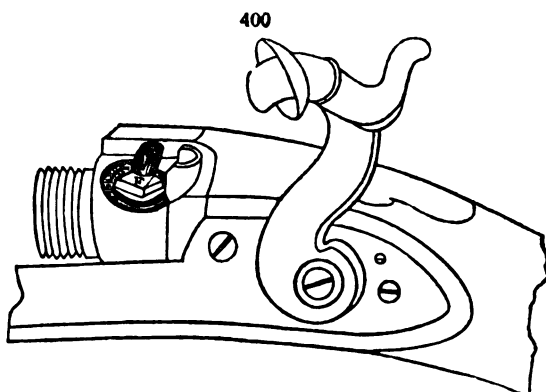
The safety lock of Dr. Somerville is a truly humane invention. Its essential feature is a slide stop or catch, placed under the trigger A, *fig.* 401. It is pulled forward into a notch in the trigger, by means of a spring B, upon the front of the guard, which is worked by a key c, pressing upon the spring when the piece is discharged. In another safety plan there is a small moveable curved piece of iron, A, which rises through an opening B, in the lock-plate c, and prevents the cock from reaching the nipple, as represented in the figure, until it is drawn back within the plate of the lock when the piece is fired.

401
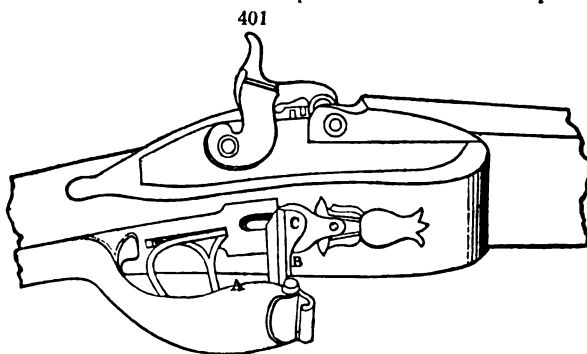
To fire this gun, two different points must be pressed at the same time. If by accident the key which works the safety be touched, nothing happens, because the trigger is not drawn; and the trigger touched alone can produce no effect, because it is locked. The pressure must be applied to the trigger and the key at the same instant, otherwise the lock will not work.

The French musket is longer than the British, in the proportion of 44·72 inches to 42; but the French bayonet is 15 inches, whereas the British is 17.

	Eng. Dimensions.	Fr. Dimensions.
Diameter of the bore - - - -	0.75 in.	0·69 in.
Diameter of the ball - - - -	0·676	0·65
Weight of the ball in oz. - - -	1·06	0·958
Weight of the firelock and bayonet in lbs. -	12·25	10·980
Length of the barrel and bayonet - -	59·00	59·72

Within these few years a great many contrivances have been brought forward, and several have been patented for fire arms. The first I shall notice is that of Charles Random, Baron de Berenger. *Fig.* 402 shows the lock and breech of a fowling piece, with a sliding protector on one of the improved plans; *a* is the hammer, *b* the nipple of the touch-hole, *c* a bent lever, turning upon a pin, fixed into the lock-plate at *d*. The upper end of this bent lever stands partly under the nose of the hammer, and while in that situation stops it from striking the nipple. A slider *g f h*, connected with the under part of the gun-stock, is attached to the tail of the bent lever at *i*; and when the piece is brought to the shoulder for firing, the hand of the sportsman pressing against the bent part of the slider at *g*, forces this back, and thereby moves the end of the lever *c* forward
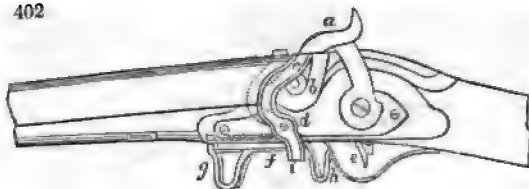
from under the nose of the cock or hammer, as shown by the dotted lines. The trigger being now drawn, the piece will be discharged; and on removing the hand from the end *g*, of the slider *f*, the spring at *h* acting against the guard, will force the slider forward, and the lever into the position first described.

Mr. Redford, gun-maker of Birmingham, proposes a modification of the lock for small fire-arms, in which the application of pressure to the sear spring for discharging the piece is made by means of a plug, depressed by the thumb, instead of the force of the finger exerted against the trigger. *Fig.* 403 represents a fowling piece partly in
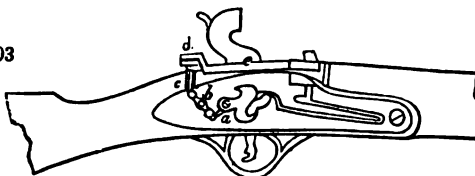
section. The sear spring is shown at *a*. It is not here connected with the trigger as in other locks; but is attached by a double-jointed piece to a lever *b*, which turns upon a fulcrum pin in its centre. At the reverse end of this lever an arm extends forwards, like that of an ordinary sear spring, upon which arm the lower end of the plug *c* is intended to bear; and when this plug is depressed by the thumb bearing upon it, that end of the lever *b* will be forced downwards, and the reverse end will be raised, so as to draw up the end of the sear spring, and set off the piece. For the sake of protection, the head of the plug *c* is covered by a moveable cap *d*, forming part of a slider *e*, which moves to and fro in a groove in the stock, behind the breech end of the barrel; this slider *e* is acted upon by the trigger through levers, which might be attached to the other side of the lock-plate; but are not shown in this figure, to avoid confusion. When the piece is brought to the shoulder for firing, the fore-finger must be applied as usual to the trigger, but merely for the purpose of drawing back the slider *e*, and uncovering the head of the plug; when this is done, the thumb is to be pressed upon the head of the plug, and will thus discharge the piece. A spring bearing against the lever of the slider *e*, will, when the finger is withdrawn from the trigger, send the slider forward again, and cover the head of the plug, as shown.

It is with pleasure I again advert to the humane ingenuity of the Rev. John Somerville, of Currie. In April, 1835, he obtained a patent for a further invention to prevent the accidental discharge of fire arms. It consists in hindering the hammer from reaching the nipple of a percussion lock, or the flint reaching the steel of an ordinary one, by the interposition of moveable safety studs or pins, which protrude from under the false breech before the hammers of the locks, and prevent them from descending to strike.

These safety studs or pins are moved out of the way by the pressure of the right hand of
the person using the gun only when in the act of firing, that is, when the force of the
right hand and arm is exerted to press the butt end of the stock of the gun against the
shoulder while the aim is taken and the trigger pulled. In carrying the gun at rest, the
proper parts of the thumb or hand do not come over Mr. Somerville's moveable buttons or
studs.

Fig. 404 is a side view of part of a double percussion gun; and *fig.* 405 is a top or
plan view, which will serve to explain these improvements, and show one, out of many,
methods of carrying them into effect. A is the stock of the gun; B the barrels; c the
breech; D the nipples; E the false breech, on the under side of which the levers which
work the safety studs or pins are placed; F is the shield of the false breech; G, triggers;
H the lock-plate; and I the hammers: all of which are constructed as usual: *a a* are
the safety studs or pins, which protrude before the shield F, and work through guide
pieces on the under side of the false breech. The button piece is placed in the
position for the thumb of the right hand to act upon it; but when the pressure of the
ball of the right thumb is to produce the movement of the safety studs, it must be placed

404
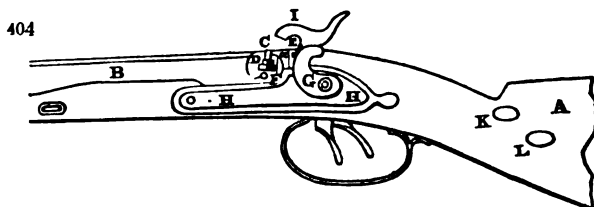
in or near the position K; and when the heel of the right hand is to effect the move-
ments of the safety studs, the button piece must be placed at L, or nearly so.

405   D   406 *u*
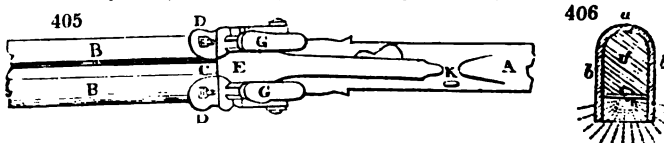
In these last two positions, the lever (which is acted upon by the button piece to work
the safety studs through a slide) would require to be of a different shape and differ-
ently mounted. When the hammers are down upon the nipples after discharging the
gun, the ends of the safety pins press against the inner sides of the hammers. When this
invention is adapted to single-barrelled guns, only one pin, *a*, one lever and button piece
will be required.

Mr. Richards, gun-maker, Birmingham, patented, in March, 1836, a modification of
the copper cap for holding the percussion powder, as represented *fig.* 406; in which
the powder is removed from the top of the cap, and brought nearer the mouth; *a* being
the top, *b* the sides, and *c* the position of the priming. The dotted lines show the direc-
tion of the explosion, whereby it is seen that the metal case is opened or distended only
in a small degree, and not likely to burst to pieces, as in the common caps, the space
between *a* and *c* being occupied by a piece of any kind of hard metal *d*, soldered or other-
wise fastened in the cap.

George Lovell, Esq., director of the Royal Manufactory of Arms at Enfield, has re-
cently made a great improvement upon the priming chamber. He forms it into a verti-
cal double cone, joined in the middle by the common apex; the base of the upper cone
being in contact with the percussion cap, presents the most extensive surface to the ful-
minate upon the one hand, while the base of the under one being in a line with the interior
surface of the barrel, presents the largest surface to the gunpowder charge, upon the
other. In the old nipple the apex of the cone being at its top, afforded very injudiciously
the *minimum* surface to the exploding force.

Guns, Rifling of the Barrels. — The outside of rifle barrels is, in general, octagonal.
After the barrel is bored, and rendered truly cylindrical, it is fixed upon the rifling
machine. This instrument is formed upon a square plank of wood 7 feet long, to which
is fitted a tube about an inch in diameter, with spiral grooves deeply cut internally
through its whole length; and to this a circular plate is attached, about 5 inches
diameter, accurately divided in concentric circles, into from 5 to 16 equal parts, and
supported by two rings made fast to the plank, in which rings it revolves. An arm
connected with the dividing graduated plate, and pierced with holes, through which a

pin is passed, regulates the change of the tube in giving the desired number of grooves to the barrel. An iron rod, with a moveable handle at the one end, and a steel cutter in the other, passes through the above rifling tube. This rod is covered with a core of lead one foot long. The barrel is firmly fixed by two rings on the plank, standing in a straight line on the tube. The rod is now drawn repeatedly through the barrel, from end to end, until the cutter has formed one groove of the proper depth. The pin is then shifted to another hole in the dividing plate, and the operation of grooving is repeated till the whole number of riflings is completed. The barrel is next taken out of the machine, and finished. This is done by casting upon the end of a small iron rod a core of lead, which, when besmeared with a mixture of fine emery and oil, is drawn, for a considerable time, by the workmen, from the one end of the barrel to the other, till the inner surface has become finely polished. The best degree of spirality is found to be from a quarter to half a revolution in a length of three feet.

Military Rifles.—An essential improvement in this destructive arm has lately been introduced into the British service at the suggestion of Mr. Lovell.

The intention in all rifles is to impart to the ball a rotatory or spinning motion round its axis, as it passes out through the barrel. This object was attained, to a certain degree, in the rifles of the old pattern, by cutting seven spiral grooves into the inside of the barrel, in the manner shown by *fig.* 407, the spherical ball, *fig.* 408, being a little

410   409   407   408
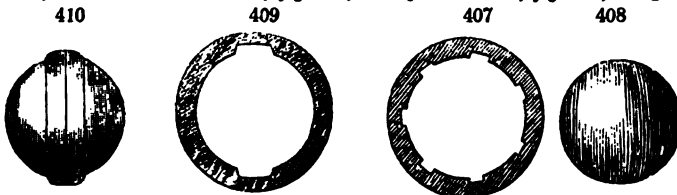
larger than the bore, was driven down with a mallet, by which the projecting ribs were forced into the surface of the ball, so as to keep it in contact with their curvatures, during its expulsion. Instead of this laborious and insecure process, the barrel being now cut with only two opposite grooves, *fig.* 409, and the ball being formed with a projecting belt, or zone, round its equator, of the same form as the two grooves, *fig.* 410, it enters so readily into these hollows, that little or no force is required to press it down upon the powder. So much more hold of the barrel is at the same time obtained, that instead of one *quarter* of a turn, which was the utmost that could be safely given in the old way, without danger of stripping the ball, a *whole* turn round the barrel, in its length, can be given to the two grooved rifles; whereby a far more certain and complete rotatory motion is imparted to the ball. The grand practical result is, that better practice has been performed by several companies of the Rifle Corps, at 300 yards, than could be produced with the best old military rifles at 150 yards; the soldier being meanwhile enabled to load with much greater ease and despatch. The belt is bevelled to its middle line, and not so flat as shown in the figure.

This mode of rifling is not, however, new in England. In fact, it is one of the oldest upon record; and appears to have fallen into disuse from faults in the execution. The idea was revived within the last few years in Brunswick, and it was tried in

411
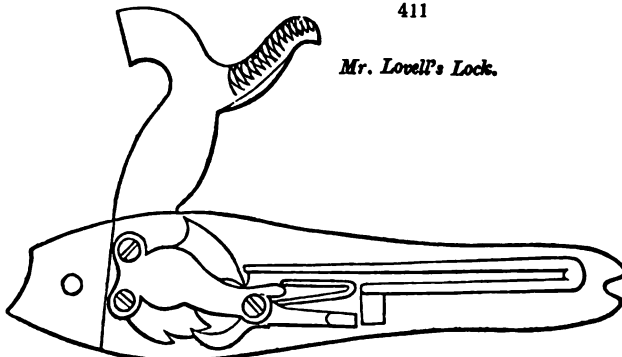
Mr. Lovell's Lock.

Hanover also, but with a lens-shaped (Linsenförmig) ball. The judicious modifications and improvements it has finally received in Mr. Lovell's hands, have brought out all its

advantages, and rendered it, when skilfully used, a weapon of unerring aim, even at the prodigious distance of 700 yards.

The locks, also, for the military service generally, are now receiving an important improvement by means of his labors, having been simplified in a remarkable manner. The action of the main spring is reversed, as shown by *fig.* 411; thus rendering the whole mechanism more solid, compact, and convenient; while the ignition of the charge being effected by percussion powders in a copper cap, the fire of the British line will, in future, be more murderous than ever, as a mis-fire is hardly ever experienced with the fire-arms made at the Royal manufactory, under Mr. Lovell's skilful superintendence.

FIRE-DAMP; the explosive carbureted hydrogen of coal mines. See PITCOAL.

FIRE-WORKS. (*Feux d'artifice,* Fr.; *Feuerwerke,* Germ.) The composition of luminous devices with explosive combustibles, is a modern art resulting from the discovery of gunpowder. The finest inventions of this kind are due to the celebrated Ruggieri, father and son, who executed in Rome and Paris, and the principal capitals of Europe, the most brilliant and beautiful fireworks that were ever seen. The following description of their processes will probably prove interesting to many of my readers.

The three prime materials of this art are, nitre, sulphur, and charcoal, along with filings of iron, steel, copper, zinc, and resin, camphor, lycopodium, &c. Gunpowder is used either in grain, half crushed, or finely ground, for different purposes. The longer the iron filings, the brighter red and white sparks they give; those being preferred which are made with a very coarse file, and quite free from rust. Steel filings and cast-iron borings contain carbon, and afford a more brilliant fire, with wavy radiations. Copper filings give a greenish tint to flame; those of zinc, a fine blue color; the sulphuret of antimony gives a less greenish blue than zinc, but with much smoke; amber affords a yellow fire, as well as colophony, and common salt; but the last must be very dry. Lampblack produces a very red color with gunpowder, and a pink with nitre in excess. It serves for making golden showers. The yellow sand or glistening mica, communicates to fire-works golden radiations. Verdigris imparts a pale green; sulphate of copper and sal-ammoniac, a palm-tree green. Camphor yields a very white flame and aromatic fumes, which mask the bad smell of other substances. Benzoin and storax are used also on account of their agreeable odor. Lycopodium burns with a rose color and a magnificent flame; but it is principally employed in theatres to represent lightning, or to charge the torch of a fury.

Fire-works are divided into three classes: 1. those to be set off upon the ground; 2. those which are shot up into the air; and 3. those which act upon or under water.

Composition for *jets of fire;* the common preparation for rockets not more than ⅔ of an inch in diameter, is; gunpowder, 16 parts; charcoal, 3 parts. For those of larger diameter; gunpowder, 16; steel filings, 4.

Brilliant revolving wheel; for a tube less than ⅔ of an inch; gunpowder, 16; steel filings, 3. When more than ⅔: gunpowder, 16; filings, 4.

Chinese or Jasmine fire; when less than ⅔ of an inch: gunpowder, 16; nitre, 8; charcoal (fine), 3; sulphur, 3; pounded cast-iron borings (small), 10. When wider than ⅔: gunpowder, 16; nitre, 12; charcoal, 3; sulphur, 3; coarse borings, 12.

A fixed brilliant; less than ⅔ in diameter: gunpowder, 16; steel filings, 4; or, gunpowder, 16; and finely pounded borings, 6.

Fixed suns are composed of a certain number of jets of fire distributed circularly, like the spokes of a wheel. All the fusees take fire at once through channels charged with quick matches. *Glories* are large suns with several rows of fusees. *Fans* are portions of a sun, being sectors of a circle. The *Patte d'oie* is a fan with only three jets.

The *mosaic* represents a surface covered with diamond shaped compartments, formed by two series of parallel lines crossing each other. This effect is produced by placing at each point of intersection, four jets of fire, which run into the adjoining ones. The intervals between the jets must be associated with the discharge of others, so as to keep up a succession of fires in the spaces.

Palm trees. Ruggieri contrived a new kind of fire, adapted to represent all sorts of trees, and especially the palm. The following is the composition of this magnificent green fire-work: crystallized verdigris, 4 parts; sulphate of copper, 2; sal-ammoniac, 1. These ingredients are to be ground and moistened with alcohol. An artificial tree of any kind being erected, coarse cotton rovings about 2 inches in diameter, impregnated with that composition, are to be festooned round the trunk, branches, and among the leaves; and immediately kindled before the spirits have had time to evaporate.

Cascades imitate sheets or jets of water. The Chinese fire is best adapted to such decorations.

Fixed stars. The bottom of a rocket is to be stuffed with clay, and one diameter in height of the first preparation being introduced, the vacant space is to be filled with the following composition, and the mouth tied up. The pasteboard must be pierced into the preparation, with five holes, for the escape of the luminous rays, which represent a star.

Composition of fixed stars :—

	Ordinary.	Brighter.	Colored.
Nitre - -	- 16	12	0
Sulphur -	- 4	6	6
Gunpowder meal	- 4	12	16
Antimony -	- 2	1	2

Lances are long rockets of small diameter, made with cartridge paper. Those which burn quickest should be the longest. They are charged by hand without any mould, with rods of different lengths, and are not strangled at the mouth, but merely stuffed with a quick match of tow. These lances form the figures of great decorations; they are fixed with sprigs upon large wooden frame works, representing temples, palaces, pagodas, &c. The whole are placed in communication by *conduits*, or small paper cartridges like the lances, but somewhat conical, that they may fit endwise into one another to any extent that may be desired. Each is furnished with a match thread fully 1½ inches long, at its two ends.

Composition for the *white lances:* nitre, 16; sulphur, 8; gunpowder, 4 or 3. For a *bluish-white:* nitre, 16; sulphur, 8; antimony, 4. For *blue lances:* nitre, 16; antimony, 8. For *yellow:* nitre, 16; gunpowder, 16; sulphur, 8; amber, 8. For *yellower* ones: nitre, 16; gunpowder, 16; sulphur, 4; colophony, 3; amber, 4. For *greenish* ones: nitre, 16; sulphur, 6; antimony, 6; verdigris, 6. For *pink lances:* nitre, 16; gunpowder, 3; lampblack, 1. Others less vivid are made with nitre, 16; colophony, 3; amber, 3; lycopodium, 3.

Cordage is represented in fire-works, by imbuing soft ropes with a mixture of nitre, 2; sulphur, 16; antimony, 1; resin of juniper, 1.

The Bengal flames rival the light of day. They consist of, nitre, 7; sulphur, 2; antimony, 1. This mixture is pressed strongly into earthen porringers, with some bits of quick match strewed over the surface. These flames have a fine theatrical effect for conflagrations.

Revolving suns are wheels upon whose circumference rockets of different styles are fixed, and which communicate by *conduits*, so that one is lighted up in succession after another. The composition of their common fire is, for sizes below ⅔ of an inch: gunpowder meal, 16; charcoal, not too fine, 3. For larger sizes: gunpowder, 20; charcoal, not too fine, 4. For *fiery radiations:* gunpowder, 16; yellow micaceous sand, 2 or 3. For *mixed radiations:* gunpowder, 16; pitcoal, 1; yellow sand, 1 or 2.

The *waving or double Catharine wheels* are two suns turning about the same axis in opposite directions. The fusees are fixed obliquely and not tangentially to their peripheries. The wheel spokes are charged with a great number of fusees; two of the four wings revolve in the one direction, and the other two in the opposite; but always in a vertical plane.

The *girandoles, caprices, spirals,* and some others, have, on the contrary, a horizontal rotation. The fire-worker may diversify their effects greatly by the arrangement and color of the jets of flame. Let us take for an example the *globe of light.* Imagine a large sphere turning freely upon its axis, along with a hollow hemisphere, which revolves also upon a vertical axis passing through its under pole. If the two pieces be covered with colored lances or cordage, a fixed luminous globe will be formed; but if horizontal fusees be added upon the hemisphere, and vertical fusees upon the sphere, the first will have a relative horizontal movement, the second a vertical movement, which being combined with the first, will cause it to describe a species of curve, whose effect will be an agreeable contrast with the regular movement of the hemisphere. Upon the surface of a revolving sun, smaller suns might be placed, to revolve like satellites round their primaries.

Ruggieri exhibited a luminous serpent, pursuing, with a rapid winding pace, a butterfly which flew continually before it. This extraordinary effect was produced in the following way. Upon the summits of an octagon he fixed eight equal wheels turning freely upon their axles, in the vertical plane of the octagon. An endless chain passed round their circumference, going from the interior to the exterior, covering the outside semi-circumference of the first, the inside of the second, and so in succession; whence arose the appearance of a great festooned circular line. The chain, like that of a watch, carried upon a portion of its length a sort of scales pierced with holes for receiving colored lances, in order to represent a fiery serpent. At a little distance there was a butterfly constructed with white lances. The piece was kindled commonly by other fireworks, which seemed to end their play, by projecting the serpent from the bosom of the flames. The motion was communicated to the chain by one of the wheels, which received it like a clock from the action of a weight. This remarkably curious mechanism was called by the artists a *salamander.*

The rockets which rise into the air with a prodigious velocity are among the most

common, but not least interesting fire-works. When employed profusely, they form those rich volleys of fire which are the crowning ornaments of a public fête. The cartridge is similar to that of the other jets, except in regard to its length, and the necessity of pasting it strongly, and planing it well; but it is charged in a different manner. As the sky-rockets must fly off with rapidity, their composition should be such as to kindle instantly throughout their length, and extricate a vast volume of elastic fluids. To effect this purpose, a small cylindric space is left vacant round the axis; that is, the central line is tubular. The fire-workers call this space the soul of the rocket (*ame de la fusée*). On account of its somewhat conical form, hollow rods, adjustable to different sizes of broaches or skewers, are required in packing the charge; which must be done while the cartridge is sustained by its outside mould, or copper cylinder. The composition of sky-rockets is as follows:—

When the bore is	¾ of an inch :	¾ to 174 ;	1¾ ;
Nitre - - -	16	16	16
Charcoal - -	7	8	9
Sulphur - -	4	4	4
Brilliant Fire.			
Nitre - - -	16	16	16
Charcoal - -	6	7	8
Sulphur - -	4	4	4
Fine steel filings -	3	4	5
Chinese Fire.			
Nitre - - -	16	16	16
Charcoal - -	4	5	6
Sulphur - -	3	3	4
Fine borings of cast-iron	3 coarser	4 mixed	5

The cartridge being charged as above described, the *pot* must be adjusted to it, with the *garniture;* that is, the serpents, the crackers, the stars, the showers of fire, &c. The pot is a tube of pasteboard wider than the body of the rocket, and about one third of its length. After being strangled at the bottom like the mouth of a vial, it is attached to the end of the fusee by means of twine and paste. These are afterwards covered with paper. The garniture is introduced by the neck, and a paper plug is laid over it. The whole is enclosed within a tube of pasteboard terminating in a cone, which is firmly pasted to the pot. The quick-match is now finally inserted into the *soul* of the rocket. The rod attached to the end of the sky-rockets to direct their flight is made of willow or any other light wood. M. Ruggieri replaced the rod by conical wings containing explosive materials, and thereby made them fly further and straighter.

The *garnitures* of the sky-rocket pots are the following:—

1. *Stars* are small, round, or cubic solids, made with one of the following compositions, and soaked in spirits. *White stars*, nitre, 16; sulphur, 8; gunpowder, 3. Others more vivid consist of nitre, 16; sulphur, 7; gunpowder, 4.

Stars for golden showers, nitre, 16; sulphur, 10; charcoal, 4; gunpowder, 16; lampblack, 2. Others yellower are made with nitre, 16; sulphur, 8; charcoal, 2; lampblack, 2; gunpowder, 8.

The *serpents* are small fusees made with one or two playing cards; their bore being less than half an inch. The *lardons* are a little larger, and have three cards; the *retilles* are smaller. Their composition is, nitre, 16; charcoal, not too fine, 2; gunpowder, 4; sulphur, 4; fine steel filings, 6.

The *petards* are cartridges filled with gunpowder and strangled.

The *saxons* are cartridges clayed at each end, charged with the brilliant turning fire, and perforated with one or two holes at the extremity of the same diameter.

The *cracker* is a round or square box of pasteboard, filled with granulated gunpowder, and hooped all round with twine.

Roman candles are fusees which throw out very bright stars in succession. With the composition (as under) imbued with spirits and gum-water, small cylindric masses are made, pierced with a hole in their centre. These bodies, when kindled and projected into the air, form the stars. There is first put into the cartridge a charge of fine gunpowder of the size of the star; above this charge a star is placed; then a charge of composition for the Roman candles.

The *stars*, when less than ⅔ of an inch, consist of nitre, 16; sulphur, 7; gunpowder, 5. When larger, of nitre, 16; sulphur, 8; gunpowder, 8.

Roman candles, nitre, 16; charcoal, 6; sulphur, 3. When above ⅔ of an inch, nitre, 16; charcoal, 8; sulphur, 6.

The *girandes*, or bouquets, are those beautiful pieces which usually conclude a fire-

work exhibition; when a multitude of jets seem to emblazon the sky in every direction, and then fall in golden showers. This effect is produced by distributing a number of cases open at top, each containing 140 sky-rockets, communicating with one another by quick-match strings planted among them. The several cases communicate with each other by *conduits*, whereby they take fire simultaneously, and produce a volcanic display.

The *water fire-works* are prepared like the rest; but they must be floated either by wooden bowls, or by discs and hollow cartridges fitted to them.

Blue fire for lances may be made with nitre, 16; antimony, 8; very fine zinc filings, 4. Chinese paste for the stars of Roman candles, bombs, &c. :—Sulphur, 16; nitre, 4; gunpowder meal, 12; camphor, 1; linseed oil, 1; the mixture being moistened with spirits.

The *feu grégois* of Ruggieri, the son :—Nitre, 4; sulphur, 2; naptha, 1. See PYRO-TECHNY and ROCKETS.

The red fire composition is made by mixing 40 parts of nitrate of strontia, 13 of flowers of sulphur, 5 of chlorate of potash, and 4 of sulphuret of antimony.

White fire is produced by igniting a mixture of 48 parts nitre; $13\frac{1}{2}$ sulphur; $7\frac{1}{2}$ sulphuret of antimony; or, 24 nitre, 7 sulphur, 2 realgar; or, 75 nitre, 24 sulphur, 1 charcoal; or, finally, 100 of gunpowder meal, and 25 of cast-iron fine borings.

The blue fire composition is 4 parts of gunpowder meal; 2 of nitre; sulphur and zinc, each 3 parts.

FISH-HOOKS (*Hamecons*, Fr.; *Fishangeln*, Germ.) are constructed with simple tools, but require great manual dexterity in the workmen. The iron wire of which they are made should be of the best quality, smooth, and sound. A bundle of such wire is cut in lengths, either by shears or by laying it down upon an angular wedge of hard steel fixed horizontally in a block or anvil, and striking off the proper lengths by the blows of a hammer. In fashioning the *barbs* of the hooks the straight piece of wire is laid down in the groove of an iron block made on purpose, and is dexterously struck by the chisel in a slanting direction, across so much of the wire as may be deemed necessary. A sharp-pointed little wedge is thus formed, whose base graduates into the substance of the metal.

The end of the wire where the line is to be attached is now flattened or screw-tapped; the other-end is sharp pointed, and the proper twisted curvature is given. The soft iron hooks are next case-hardened, to give them the steely stiffness and elasticity, by imbedding them in animal charcoal contained in an earthen or iron box; see CASE-HARD-ENING; after which they are brightened by heating and agitating them with bran, and finally tempered by exposure to a regulated temperature upon a hot iron plate. Hooks for salt-water fishing are frequently tinned, to prevent them wearing rapidly away in rust. See TIN PLATE.

FLAKE WHITE is the name sometimes given to pure white-lead.

FLAME (*Flamme*, Fr. and Germ.) is the combustion of an explosive mixture of an inflammable gas or vapor with air. That it is not, as many suppose, combustion merely at the exterior surface, is proved by plunging a fragment of burning phosphorus or sulphur into the centre of a large flame of alcohol. Either of these bodies will continue to burn there with its peculiar light; thus proving that oxygen is mixed with the whole of the burning vapor. If we mix good coal gas with as much atmospheric air as can convert all its carbon into carbonic acid, the mixture will explode with a feeble blue light; but if we mix the same gas with a small quantity of air, it will burn with a rich white flame. In the latter case the carbonaceous particles are precipitated, as Sir H. Davy first showed, in the interior of the flame, become incandescent, and constitute white light: for from the ignition of solid matter alone can the prismatic rays be emitted in that concentrated union. Towards the interior of the flame of a candle, a lamp, or a gas jet, where the air is scanty, there is a deposition of solid charcoal, which first by its ignition, and afterwards by its combustion, increases in a high degree the intensity of the light. If we hold a piece of fine wire gauze over a jet of coal gas close to the orifice, and if we then kindle the gas, it will burn above the wire with its natural brilliancy; but if we elevate the gauze progressively higher, so as to mix more and more air with it before it reaches the burning point, its flame will become fainter and less white. At a certain distance it becomes blue, like that of the above explosive mixture. Since the combustion of all the constituents is in this case direct and complete, the heat becomes greatest in proportion nearly as the light is diminished. If a few platina wires be held in that dim flame they will grow instantly white hot, and illuminate the apartment. On reversing the order of this experiment, by lowering progressively a flat piece of wire gauze from the summit towards the base of a gas flame, we shall find no charcoal deposited at its top, because plenty of air has been introduced there to convert all the carbon of the gas into carbonic acid, and therefore the apex is blue; but as we descend, more and more charcoal will appear upon the meshes. At the very bottom, indeed, where the

atmospheric air impinges upon the gauze, the flame is again blue, and no charcoal can therefore be deposited.

The fact of the increase of the brilliancy and whiteness of flame by the development and ignition of solid matter in its bosom illustrates many curious phenomena. We can thus explain why olefiant gas affords the most vivid illumination of all the gases; because, being surcharged with charcoal, its hydrogen lets it go in the middle of the flame, as it does in an ignited porcelain tube, whereby its solid particles first get ignited to whiteness, and then burn away. When phosphorus is inflamed it always yields a pure white light, from the ignition of the solid particles of the snowy acid thus produced.

In the blowpipe the inner blue flame has the greatest heat, because there the combustion of the whole fatty vapor is complete. The feeble light of burning hydrogen, carbonic oxyde, and sulphur, may, upon the principles now expounded, be increased by simply placing in them a few particles of oxyde of zinc, slender filaments of amianthus, or fine platina wire. Upwards of twenty years ago I demonstrated, in my public lectures in Glasgow, that by narrowing the top of a long glass chimney over an argand flame either from oil or coal gas, the light could be doubled at the same cost of material. The very tall chimneys used by the Parisian lampists are very wasteful. I find that with a narrow chimney of half the length of theirs, I can have as good a light, and save 30 per cent. of the oil. Thus the light of a flame may be increased by diminishing its heat, or the intensity of its combustion; and conversely the heat of a flame may be increased by diminishing its light.

FLANNEL; a plain woollen stuff, of a rather open and slight fabric.

FLAX. By this term we understand the *bast* or inner bark of the *Linum usitatissimum*, which is spun into yarn for weaving linen webs. This plant blossoms in June or July, and commonly ripens its seed in September. As varieties, we distinguish the *spring* flax, with short knotty stems, whose seed capsules, at the period of maturity, spring open with a perceptible sound; and the *close* flax, with longer smoother stems, whose capsules give out their seeds only when thrashed. The Germans, who have bestowed much attention upon the culture of flax, call the former *Klanglein* or *Springlein*, and the latter *Dreschlein*. This is the kind most commonly grown, but from the difference of climate, soil, and culture, it affords flax of very different qualities. The best ground for this plant is an open, somewhat friable clay, mingled with sand and mould. The early flax is usually sown in the end of April or beginning of May, the late, in June. The seeds ought to be sown thick, whereby the stalks are forced to grow more slender, and the fibres of the bast or harl are not only smoother and finer, but more uniform in length. If the raising of seed be the principal object, the flax must be more thinly sown, whereby it will produce stronger stalks, but more knotty, with shorter fibres, and more productive of tow.

Whenever the flax is ripe, which is shown by the bottom of the stalk becoming yellow and the leaves beginning to drop off, it must be immediately reaped by pulling it up by the roots. The seeds are still immature, fit merely for the oil press, and not for sowing When the seed crop is the object, the plant must be suffered to acquire its full maturity; in which case the fibres are less fine and soft.

The flax is carried off the field in bundles to be rippled, or stripped of its seeds, which is done by drawing it by handfuls through an iron comb with teeth eight inches long, fixed upright in a horizontal beam. When the seeds are more fully ripened, they may be separated by the thrashing mill.

The operations next performed upon the flax will be understood by attending to the structure of the stem. In it two principal parts are to be distinguished; the woody heart or ·boon, and the *harl* (covered outwardly with a fine cuticle), which encloses the former like a tube, consisting of parallel lines. In the natural state, the fibres of the harl are attached firmly, not only to the boon, but to each other, by means of a green or yellowish substance. The rough stems of the flax, after being stripped of their seeds, lose in moisture, by drying in warm air, from 55 to 65 per cent. of their weight; but somewhat less when they are quite ripe and woody. In this dry state they consist in 100 parts of from 20 to 23 per cent. of *harl*, and from 80 to 77 per cent. of boon. The latter is composed upon the average of 69 per cent. of a peculiar woody substance, 12 per cent. of a matter soluble in water, and 19 per cent. of a body not soluble in water, but in alkaline leys. The *harl* contains at a mean 58 per cent. of pure flaxen fibres, 25 parts soluble in water (apparently extractive and albumen), and 17 parts insoluble in water, being chiefly gluten. By treating the harl with either cold or hot water, the latter substance is dyed brown by the soluble matter, while the fibres retain their coherence to one another. Alkaline leys, and also, though less readily, soap water, dissolve the gluten, which seems to be the cement set them free.

The cohesion of the fibres in the rough harl is so considerable that by mechanical means, as by beating, rubbing, &c., a complete separation of them cannot be effected, unless with great loss of time and rupture of the filaments. This circumstance

shows the necessity of having recourse to some chemical method of decomposing the gluten. The process employed with this view is a species of fermentation, to which the flax stalks are exposed; it is called *retting*, a corruption of rotting, since a certain degree of putrefaction takes place. The German term is *rusting*. This is the first important step in the preparation of flax. After the retting is completed, the boon of the stalks must be removed by the second operation called *breaking*, and other subordinate processes. The harl freed from the woody parts contains still a multitude of fibres, more or less coherent, or entangled, and of variable lengths, so as to be ill adapted for spinning. These are removed by the *heckle*, which separates the connected fibres into their finest filaments, removes those that are too short, and disentangles the longer ones.

I. *Of retting.*—The fermentation of this process may be either rendered rapid by steeping the flax in water, or slow by using merely the ordinary influence of the atmospheric damp, dews, and rain. Hence the distinction of water-retting and dew-retting. Both may also be combined.

Prior to being retted, the flax should be sorted according to the length and thickness of its stalks, and its state of maturity : the riper the plant, the longer must the retting last. The due length of the process is a point too little studied.

Water-retting.—When flax stalks are macerated in water, at a temperature not too low, fermentation soon begins, evinced in the dingy infusion, by disengagement of carbonic acid gas, and the production of vinegar. If the flax be taken out at the end of a few days, dried, and rubbed, the textile filaments are found to be easily separable from each other. By longer continuance of the steep, the water ceases to be acid, it becomes to a certain degree alkaline, from the production of ammonia, diffuses a fetid odor, from the disengagement of sulphureted hydrogen gas, along with the carbonic acid; the acetous fermentation being in fact now changed into the putrid. The filaments become yellowish brown, afterwards dark brown, and lose much of their tenacity, if the process be carried further.

When the operation is conducted with discernment, the water-retting may be completed by the acetous fermentation alone, as the putrefaction should never be suffered to proceed to any length; because when over-retted, flax is partially rotten, gets a bad color, and yields a large proportion of tow.

For water-retting, the flax must be bound up in sheaves, placed in layers over each other in the water, or sometimes upright, with the roots undermost. Straw may be put below to keep it from touching the ground, and boards may be laid upon the top, with weights to hold it immersed about a foot beneath the surface, especially when the fermentative gases make it buoyant. As soon as it sinks at the end of the fermentation, it must be inspected at least twice a day, and samples must be taken out to see that no over-retting ensues. A single day too long often injures the flax not a little. We may judge that the retting is sufficient when the harl separates easily from the boon by the fingers, when the boon breaks across without bending, and when several stalks knotted together sink to the bottom upon being thrown into the water. For this completion, a shorter or longer time is required according to the quality of the flax, the temperature, &c., so that the term may vary from five to fourteen days. It may be done either in running or in stagnant water. For the latter purpose, tanks five feet deep are dug in the ground. In stagnant water, the process is sooner finished, but it is more hazardous, and gives a deeper stain to the fibres, than in a stream, which carries off much of the color. The best place for steeping flax is a pond with springs of water at its bottom; or a tank into which a rivulet of water can be occasionally admitted, while the foul water is let off. For every fresh quantity of flax, the pond should be emptied, and supplied with clear water. Water impregnated with iron, stains flax a permanent color, and should therefore never be used. After retting, the flax should be taken out without delay, rinsed in clean water, and exposed in an airy situation to dry by the sun.

Rough rippled flax stalks, well seasoned before being retted, and dried afterwards, show a loss of weight, amounting to 20 or 30 per cent., affecting both the boon and the harl. This loss is greater the finer the stems, and the longer the retting. The harl contains, beside the textile filaments, a certain portion of a glutinous cement; but nothing soluble in water. The destruction of the gluten cannot be pushed to the last point by steeping, without doing an essential injury to the filaments.

Dew-retting.—The fetid and noxious exhalations which the water-retting diffuses over an extensive district of country, and the danger of over-retting in that way, especially with stagnant water, are far from recommending that process to general adoption. Dew-retting accomplishes the same purpose, by the agency of the air, dews, and rain, in a much more convenient, though far slower manner. The flax, with this view, should be spread out thin upon meadow or grass lands, but never upon the bare ground, and turned over, from time to time, till the stems, on being rubbed between the fingers, show that the harl and the boon are ready to part. The duration of dew-retting is, of course, very various, from 2 to 6, or 8 weeks, as it depends upon the state

of the weather; a moist air being favorable, and dry sunshine the reverse. The loss of weight by dew-retting is somewhat less than by water-retting; and the textile fibres are of a brighter color, softer and more delicate to the touch.

Mixed retting.—This may be fairly regarded as the preferable plan, the retting being begun in the water, and finished in the air. The flax should be taken out of the steep whenever the acetous fermentation is complete, before the putrid begins, and exposed, for 2 or 3 weeks, on the grass.

II. *The breaking* is performed by an instrument called a brake. In order to give the wood or boon such a degree of brittleness as to make it part readily from the harl, whereby the execution of this process is rendered easy, the flax should be well dried in the sun, or what is more suitable to the late period of the year, in a stove. Such is often attached to the bakers' ovens in Germany, and other flax-growing countries. The drying temperature should never exceed 120° F., for a higher heat makes it brittle, easy to tear, and apt to run into tow. Before subjecting the flax to the brake, the stems should be equalised and laid parallel by the hand, and the entangled portions should be straightened with a coarse heckle. The brake has one general construction, and consists of two principal parts, the frame or case, and the sword or beater. In the simplest brakes, the frame *e*, *fig.* 412, is a piece of wood cleft lengthwise in the middle, supported by the legs *a* and *c*. The sword *f*, also of hard wood, is formed with an edge beneath, and turns round the centre of motion at *q*, when seized by the handle *h*, and moved up and down. As it descends, the sword enters the cleft of the frame, and breaks the flax stalks laid transversely upon it, scattering the boon in fragments.

But those hand brakes are more convenient which are provided with a double cleft, or triple row of oblong teeth, with a double sword. This construction will be understood by inspecting *figs.* 412, 413, 414. *Fig.* 412 is the section of that side at which the operative sits; *fig.* 413 is a section in the line A, B, of *fig.* 412; and *fig.* 414 the ground plan. The whole machine is made of hard wood, commonly red beech. Two planks *a* and *c*, form the legs of the implement. *a* is mortised in a heavy block, to give the brake a solid bearing; two stretchers *d*, bind *a* and *c*, firmly together. The frame *e* consists of three thin boards, which are placed edgewise, and have their ends secured in *a* and *c*. The sword *f* is a piece of wood, so chamfered from *i* to *k*, that it appears forklike, and embraces the middle piece of the frame; its centre of motion is the wooden pin *q*; in front is the handle *h*, which the operative seizes with the right hand. Both the lathes of the frame and those of the sword are sharpened, from *l* to the front end, as is best shown in *fig.* 413; but the edges must not be too sharp, for fear of injuring the flax; and, for the same reason, the sword should not sink too far between the lathes of the frame. Such hand-brakes are laborious in use, and often tear the harl into tow. The operative, usually a female, in working the brake, seizes with her left hand a bundle of flax, lays it transversely across the frame, and strikes it smartly with repeated blows of the sword, pushing forwards continually new portions of the flax into the machine. She begins with the roots, turns next round the tips, then goes on through the length of the stalks. Flax is frequently exposed twice to the brake, with a stove drying between the two applications.

The brake machines afford a far preferable means of cleaning flax than the above hand tools. The essential part of such a machine, consists in several deeply fluted rollers of wood or iron, whose teeth work into each other, and while they stretch out the flaxen stalks betwixt them, they break the wood or boon, without doing that violence to the harl which hand mechanisms are apt to do. The following may be regarded as

one of the best constructions hitherto contrived for breaking flax. *Fig.* 415 is a view of the right side of this machine. *Fig.* 416 the view from behind, where the broken

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flax issues from between the rollers.   The frame is formed by the two side pillars or walls *a, a,* which are mortised into the bottom *b, b;* and are firmly fixed to it by braces.   Two transverse rods *d, d,* secure the base, two others *d′ d″,* the sides.   In each of these a lateral arm *e,* is mortised in an oblique direction; a cross bar *f,*

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unites both arms.   *Fig.* 417 shows the inside of the left side of the frame, with the subsidiary parts.   The three rollers *g, i, k,* may be made of red beech, with iron gudgeons, and fluted in their length, each of the flutes being $\frac{5}{12}$ths of an inch broad, and $\frac{4}{12}$ths deep. The large roller *g,* bears upon the right side, a handle *h,* which on being turned, sets the whole train in motion. The side partitions *a, a,* are furnished with brasses in whose round holes *l, g, fig.* 417, the gudgeons *g* work.   For the extremities of the two smaller rollers, there are at *u* and *e,* slots in brasses, as may be seen in *fig.* 415. Within the partition *a,* there are moveable brasses *l,* for the pivots of *i* and *k,* shown in *fig.* 417.   Each brass slides in a groove, between two ledges.   A strong cord made fast at *m* to the partition *a,* runs over the brass of *i,* next over that of *k,* then descends perpendicularly, and passes over the cross bar *n, figs.* 415 and 416.   This construction being repeated at both ends of the rollers, the rod *n,* binds both cords. Against the cross bar *d′* of the frame, a lever *o* is sustained, which lies upon the rod *n,* and carries a weight *p.*   The farther or nearer this weight hangs towards the end of the lever, it stretches the cord more or less, and presses by means of the brasses *l,* the rollers *i, k,* towards the main roller *g.*   A table *q,* serves for spreading out the flax to be broken, and a second one *r,* for the reception of the stalks at their issuing from between the rollers.   Both tables hang by means of iron hooks to rings of the frame *s, t, figs.* 415 and 417, and are supported by the moveable legs *u, u, u, figs.* 415 and 416.

◥

In using the machine the operative lays an evenly spread handful of flax upon the table, q, introduces their root ends with his left hand between the rollers g and i, and turns round the handle h, with the right. The stems are first broken betwixt g and i, then between g and k, and come out upon the table r. The handle is moved alternately forwards and backwards, in order that the flax may be rolled alternately in the same directions, and be more perfectly broken. The boon falls down in very small pieces, and the harl remains expanded in parallel bands. This should be drawn over the points of a heckle, then laid for a couple of days in a cellar to absorb some moisture, and afterwards worked once more through the machine, whereby the flax acquires a peculiar softness.

The advantages of this brake machine are chiefly the following :—

It takes up little room, and from its simplicity is easily and cheaply constructed; it requires no more power to work, than the ordinary hand-brake; it tears none of the filaments, and grinds nothing except the boon, in consequence of the flutings of the rollers going much less deep into each other, than the sword of the hand-brake ; it prevents all entanglements of the flax, whence in the subsequent heckling the quantity of short fibres or tow is diminished ; and it accomplishes the cleaning of even the shortest flax, which cannot be well done by hand machines.

The comminution of the boon of the stems, which is the object of the breaking process, can however be performed by thrashing or beating, although in this way the separation of the woody matter from the textile fibres is much less completely effected.

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It is the practice in Great Britain, instead of breaking, to employ a water-driven wooden mallet, between which and a smooth stone the flax is laid. In that part of Belgium where the preparation of flax has been studied, the brake is not used, but beating by means of the Bott-hammer, to the great improvement, it is said, of the flax. The Bott-hammer, fig. 418, is a wooden block, having on its under face channels or flutings, 5 or 6 lines deep, and it is fixed to a long bent helve or handle. In using it, a bundle of the dried flax stalks is spread evenly upon the floor, then powerfully beaten with the hammer, first at the roots, next at the points, and lastly in the middle. When the upper surface has been well beat in this way, it is turned over, that the under surface may get its turn. The flax is then removed, and well shaken to free it from the boon.
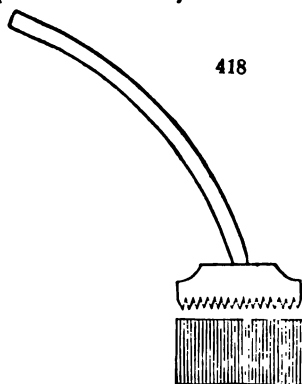
By the brake or the hammer the whole wood is never separated from the textile fibres, but a certain quantity of chaffy stuff adheres to them, which is removed by another operation. This consists either in rubbing or shaking. The rubbing is much practised in Westphalia, and the neighboring districts. In this process, the operative lays the rubbing apron on a piece of dressed leather, one foot square, upon her knee; then seizes a bundle of flax in the middle with her left hand, and scrapes it strongly with the Ribbe-knife held in her right, fig. 419. This tool, which consists of a wooden handle s, and a thin iron blade r, with a blunt and somewhat bent edge, acts admirably in cleaning and also in parting the filaments, without causing needless waste in flax previously well broken.

The winnowing, which has the very same object as the rubbing, is, however, much more generally adopted than the latter. Two distinct pieces of apparatus belong to it, namely, the swing-stock and the swing-knife. The first consists of an upright board with a groove in its side, into which a handful of flax is so placed that it hangs down over half the surface of the board. While the left hand holds the flax fast above, the right carries the swing-knife, a sabre-shaped piece of wood from 1½ to 2 feet long, planed to an edge on the convex side, and provided with a handle. With this knife the flax is struck parallel to the board, with perpendicular blows, so as to scrape off its woody asperities. The breadth of the swing-knife is an important circumstance; when too narrow it easily causes the flax to twist round it, and thereby tears away a portion of the fibres. When 8 or 10 inches broad, it is found to act best. Knives made of iron will not answer, for they injure the filaments.

Figs. 420, 421 show the best construction of the swing-stock. The board a has for its base a heavy block of wood b, upon which two upright pins e e, are fixed. The band f, which is stretched between the pins, serves to guide the swing-knife in its movements, and prevent the operative from wounding his feet. The under edge of the groove c, upon which the flax comes to be laid, is cut obliquely and rounded off (see d

in *fig.* 420); thus we perceive that the swing-knife can never strike against that edge, so as to injure the flax.

Fig. 422 exhibits the form of a very convenient implement which is employed in

Belgium instead of the swing-knife. It is a sort of wooden hatchet, which is not above two lines thick, and at the edge *g h* is reduced to the thickness of the back of a knife. The fly *k* gives force to the blow, and preserves the tool in an upright position. The short flat-pressed helve *i* is glued to that side of the leaf which in working is turned from the swing-stock; and is, moreover, fastened with a wooden pin.
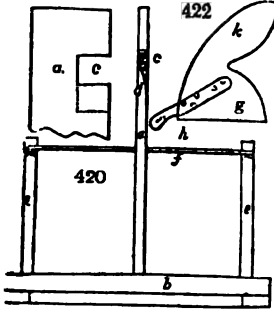
The rubbing and swinging throw off the coarsest sort of tow, by separating and shaking out the shortest fibres and those that happen to get torn. That tow is used for the inferior qualities of sacking, being mixed with many woody fibres.

We may in general estimate that 100 pounds of the stalks of retted flax, taken in the dry state, afford from 45 to 48 pounds of broken flax, of which, in the swinging or scutching, about 24 pounds of flax, with 9 or 10 pounds of scutch tow are obtained. The rest is boon-waste. The breaking of 100 pounds of stalks requires, in the ordinary routine of a double process by hand, about 20 hours; and with the above described machine, from 17 to 18 hours. To scutch 100 pounds of broken flax clean, 130 hours of labor are required by the German swinging method.

Mr. Bundy obtained a patent in 1819, for certain machinery for breaking and preparing flax, which merits description here. *Fig.* 423, A A A A, is the frame, made either of
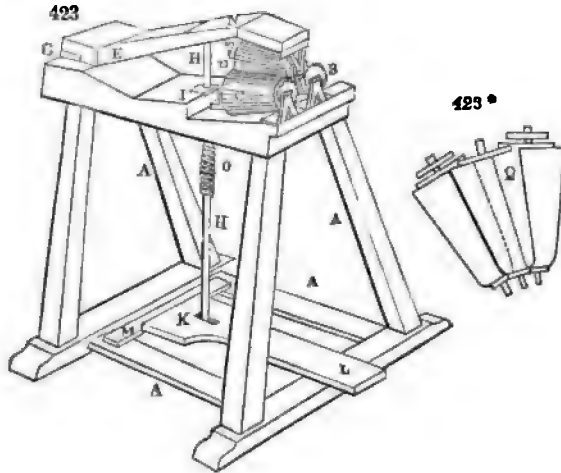
wood or metal, which supports the two conical rollers B and C. These revolve independently of each other in proper brass bearings. A third conical roller D is similarly supported under the top piece E of the machine. All these rollers are *frusta* of cones, made of cast iron. Whatever form of tooth be adopted, they must be so shaped and disposed with regard to each other as to have considerable play between them, in order to admit the quantity of flax stem which is intended to be broken and prepared. The upper piece E of the machine which carries the upper conical roller D, is fixed or attached to the main frame A A A A by strong hinges or any other moveable joint at G, and rods of iron or other sufficiently strong material; H H is attached at its upper end by a joint to the top piece E, through a hole near I, and is fixed at its lower end by another joint K to the treadle or lever K L, which turns upon the joint or hinges M. A spring or weight (but the former is preferable for many reasons) is applied to the machine in such manner, that its action will always keep the upper piece E, and consequently the upper roller D, in an elevated or raised position above the rollers B and C, when the machine is not in action; and of course the end L of the treadle will also be raised, which admits of the flax to be worked being introduced between the rollers, viz., over the two lower rollers B, C, and under the upper roller D; such a spring may be applied in a variety of ways, as between the top piece E, and the top or platform of the machine at N; or it

may be a strong spiral wire spring, having its upper end fastened to the platform while its lower extremity is fixed to the rod H H, round which it coils as shown at o, or it may be placed under the end L of the treadle; but in every case its strength must be no more than will be just sufficient to raise the upper roller D about two inches from the lower rollers, otherwise it will occasion unnecessary fatigue to the person working the machine.

The manner of using it is as follows: the upper and lower rollers being separated as aforesaid, a small handful of dried flax or hemp stems is to be introduced between them, and held extended by the two hands, while the rollers are brought together by the pressure of the foot upon the treadle L. This pressure being continued, the flax or hemp is to be drawn backwards and forwards by the hands between the rollers, in a direction at right angles to their axes, and eventually withdrawn by pulling with one hand only. The foot is now to be removed until the flax or hemp is again replaced, and each end is this way to be drawn several times through the machine, until such ends are respectively finished.

By a succession of these operations, using the pressure of the foot upon L, each time that the flax or hemp is introduced between the rollers, and regulating such pressure according to the progress of the work, the flax or hemp will soon be sufficiently worked, and the fibre brought into a clean and divided state fit for bleaching; or if it be required to spin it in the yellow state, it may be made sufficiently fine by a longer continuation of the same process, particularly if worked between the smaller ends of the rollers.

Indeed, the operation may be commenced and continued for some time, with the larger part of the rollers, and finished with their smaller ends; and, in this point of view, the invention of conical rollers will be found both convenient and useful; for as the flutes, grooves, or teeth, vary in their distance from each other at all points between the large and small ends, so it becomes almost impossible for the workman to draw the flax or hemp through such rollers in the same track; and thus the breaking of the boon must be much more irregular, and the fibre will be much more effectually cleansed than it can be by the flutes, grooves, or teeth of cylinders, or other such contrivances formerly employed; because they would probably fall frequently upon the same points of the fibres. If it is intended that the flax shall be bleached before it is spun, then the second part of Mr. Bundy's invention may be had recourse to, which consists in moving certain trays or cradles in the water, or other fluid used for bleaching the flax or hemp, in the manner following, viz.: The flax or hemp, after having been broken and worked in the machine, should be divided into small quantities of about one ounce each, and these should be tied loosely in the middle with a string, and in this state laid in the trays or cradles, and then be soaked in cold soft water for a day or two, when each parcel should be worked separately, while wet, through a machine, precisely similar to that already described, except only that the rollers should be cylindrical, and made entirely of wood with metal axles, and the teeth, which will be parallel, should be similar in form to those shown in section at q, fig. 423*. Such operation will loosen the gluten and coloring matter, for the rinsing and wringing which must follow. The flax must then be again disposed in a flat and smooth manner, in such trays or cradles, and once more set to soak in sufficient soft water to cover it, in which a small quantity of soap, in the proportion of about seven pounds of soap to each hundred weight of flax, has been previously dissolved, and in this state it should remain for two or three days longer, and then be finally worked through the machine, rinsed with clear water, and wrung; which will render it sufficiently white for most purposes.

III. *The Heckling.*—We have already stated that, by the operation of heckling, a three-fold object is proposed: 1. the parting of the filaments into their finest fibrils; 2. the separation of the short fibres which are unfit for spinning; 3. the equable and parallel arrangement of the long filaments. The instrument of accomplishing these objects is a comb fashioned tool, called the *heckle* or *hackle ;* a surface studded more or less thickly with metal points, called heckle teeth; over which the flax is drawn in such a way that the above three required operations may be properly accomplished.
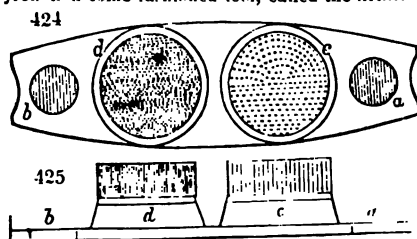
The common construction of the heckle is the following: (see *fig.* 424.) *Fig.* 424 is the ground plan, and *fig.* 425 is the section. Upon an oblong plank *a b*, two circular or square blocks of wood *c* and *d* are fixed, in which the heckle teeth stand

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upright. To give these a firmer hold they are stuck into holes in a brass or iron plate,

with which the upper surface of *c* and *d* is covered. Both heckles may be either associated upon one board or separated; and of different finenesses; that is, the teeth of the one may be thinner, and stand closer together; because the complete preparation of the flax requires, for its proper treatment, a twofold heckling; one upon the coarse, and one upon the fine heckle; nay, sometimes 3 or 4 heckles are employed of progressive fineness. The heckle teeth are usually made of iron, occasionally of steel, and from 1 to 2 inches long. Their points must be very sharp and smooth, all at an equal level, and must all graduate very evenly into a cylindrical stem, like that of a sewing needle, without any irregularity. The face of the heckle block must be uniformly beset with teeth, which is done by different arrangements, some persons setting them in a circle, and others in parallel rows; the former being practised in Germany, the latter in England. The coarse heckle is furnished with teeth about one tenth of an inch thick, one and a quarter of an inch long, and tapering from the middle into a very fine point. In the centre of the circular heckle is a tooth planted; the rest are regularly set in 12 similar concentric circles, of which the outermost is 5¾ inches in diameter. The fine heckles contain no fewer than 1109 teeth. Instead of making the points of the teeth round, it is better to make them quadrangular, in a rhombus form, in which case the edges serve to separate or dissect the fibres.

The operation of heckling is simple in principle, although it requires much experience to acquire dexterity. The operative seizes a flock of flax by the middle with the right hand, throws it upon the points of the coarse heckle, and draws it towards him, while he holds the left hand upon the other side of the heckle, in order to spread the flax, and to prevent it from sinking too deeply among the teeth. From time to time the short fibres or tow sticking to the teeth are removed. Whenever one half of the length of the strake of flax is heckled, it is turned round to heckle the other half. This process is repeated upon the fine heckle. From 100 pounds of well-cleaned flax, about 45 or 50 pounds of heckled flax may be obtained by the hand labor of 50 hours; the rest being tow, with a small waste in boony particles and dust. The process is continued, till by careful handling little more tow is formed.

Many contrivances have been made to heckle by machinery, but it may be doubted whether any of them as yet make such good work with so little loss as hand labor. In heckling by the hand, the operative feels at once the degree of resistance, and can accommodate the traction to it, or throw the flax more or less deep among the teeth, according to circumstances, and draw it with suitable force and velocity. To aid the heckle in splitting the filaments, three methods have been had recourse to; beating, brushing, and boiling with soap-water, or an alkaline ley.

Beating flax, either after it is completely heckled, or between the first and second heckling, is practised in Bohemia and Silesia. Each heckled tress of flax is folded in the middle, twisted once round, its ends being wound about with flaxen threads; and this head, as it is called, is then beat by a wooden mallet upon a block, and repeatedly turned round till it has become hot. It is next loosened out, and rubbed well between the hands. The brushing is no less a very proper operation for parting the flax into fine filaments, softening and strengthening it without risk of tearing the fibres. This process requires in tools, merely a stiff brush made of swine's bristles, and a smooth board, 3 feet long and one foot broad, in which a wooden pin is made fast. The end of the flax is twisted two or three times round this pin to hold it, and then brushed through its whole length. Well heckled flax suffers no loss in this operation; unheckled only a little tow; which is of no consequence, as the waste is thereby diminished in the following process. A cylindrical brush turned by machinery might be employed here to advantage.

The boiling of flax with potash ley alone, or with ley and soap, dissolves that portion of the glutinous cement which had resisted the retting, completes the separation of the fibres, and is therefore a good practical means of improving flax. When it is performed upon the heckled fibres, a supplementary brushing is requisite to free it from the dust, soapy particles, &c.

Can flax be prepared without retting? —The waste of time and labor in the steeping of flax; the dyeing of the fibres consequent thereon, which must be undone by bleaching; the danger of injuring the staple by the action of putrescent water; and, lastly, the diminished value of flax which is much water-retted, are all circumstances which have of late years suggested the propriety of superseding that process entirely by mechanical operations. It was long hoped, that by the employment of breaking machines, the flax merely dried could be freed from its woody particles, while the textile filaments might be sufficiently separated by a subsequent heckling. Experience has, however, proved the contrary. The machines, which consisted for the most part of fluted rollers of iron or wood, though expensive, might have been expected to separate the ligneous matter from the fibres; but, in the further working of the flax, no advantage was gained over the water-retting process.

1. Unretted flax requires a considerably longer time for breaking than retted, under the employment of the same manipulations.

2. Unretted stalks deliver in the breaking and heckling a somewhat greater product than the same weight of flax which has been retted; but there is no real advantage in this, as the greater weight of the unretted flax consists in the remainder of ligneous or glutinous matter, which being foreign to the real fibre, must be eventually removed. In the bleaching process, the water and the alkaline leys take away that matter, so that the weight of the bleached fibre is not greater from the unretted than the retted flax.

3. The parting of the fibres in the unretted stalks is imperfectly effected by the heckling, the flax either remains coarser as compared with the retted article, and affords a coarser thread, or if it be made to receive greater attenuation by a long continued heckling, it yields incomparably more torn filaments and tow.

4. The yarn of unretted flax feels harder, less glossy, and rougher; and, on account of these qualities, turns out worse in the weaving than the retted flax. Nor is the yarn of unretted flax, whether unbleached or bleached, in any degree stouter than the yarn of the retted flax.

5. Fabrics of unretted flax require for complete bleaching about a sixth less time and materials than those of the retted. This is the sole advantage, but it is more than counterbalanced by the other drawbacks above specified.

In Mr. Wordsworth's improved apparatus for heckling flax and hemp, a succession of stricks is subjected to the operation of several series of revolving heckles of different degrees of fineness, for the purpose of gradually separating or combing the long fibres, and dressing them smooth; while at the same time, the tow or entangled refuse portions of the material taken off from the stricks by the heckle points are removed from the heckles by rotatory brushes and rollers covered with wire cards, and discharged into suitable receivers, whence it may be taken to a carding engine, to be worked in the ordinary way.

The accompanying figures represent in plan and section the heckling machine, which is made double, for the purpose of allowing two series of stricks of flax to be acted upon at one time. *Fig.* 426 is a horizontal view of the machine; *fig.* 427 is an end view, the
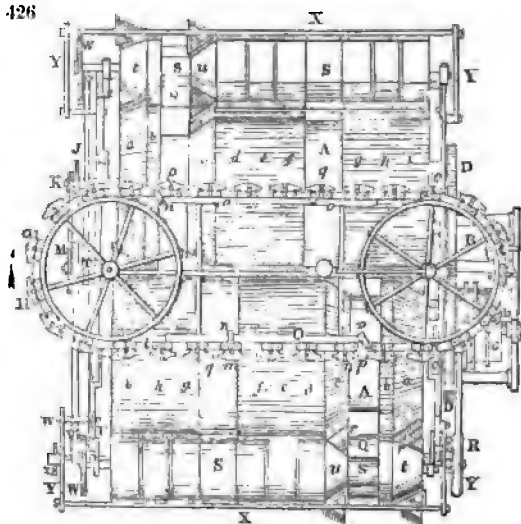
whole being represented in working order, and the respective letters of reference pointing out corresponding parts of the machine.

A A are two large barrels or drums, upon the surfaces of which are fixed longitudinally several series of brass ribs *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, holding heckle points. These ribs are placed at small distances apart round the barrels, all the heckle points standing radially from the axes, and the barrels are mounted upon axles supported by pedestals, with plummer blocks bearing on the rails of the end frames. B B, are two horizontal wheels or pulleys turning upon vertical shafts, which pulleys conduct an endless chain c c c c, carrying the holders, whereon the stricks of flax or other material intended to be heckled are suspended.

At one end of the axle of each of the barrels a toothed wheel D D is made fast, and these

are connected by a similar wheel E, and a pinion F, *fig.* 427, the latter being fixed upon the axle of the driving rigger G.

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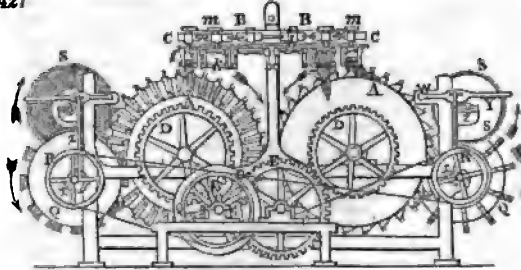
The power of a steam engine, or any other first mover, being applied by a band and rigger, or otherwise to the axle of·G, the pinion F is driven round, which, being in gearing with the toothed wheels E and D D, causes the heckle barrels A A to revolve simultaneously in opposite directions, as shown by the arrows in *fig.* 427.

The sticks of flax intended to be operated upon are severally confined between pairs of clamps *k*, fastened together, which clamps, with the sticks, are then suspended in their respective holders H H, attached to the endless chain C: the lower portion of the flax hanging down for the purpose of being acted upon by the rotatory heckles, while the upper portions are turned up in loops and confined by spring levers attached to each carrier.

The respective holders of the clamps consist of a forked frame, with hooks at the lower parts of their arms, which receive the ends of the clamps *k*, that confine the strick of flax. From the upper part of each forked frame, a perpendicular pin extends, which pins, when inserted into the sockets *l l l*, in front of the chain, form axles for the frames to turn upon at certain periods of the operation.

On the upper end of each pin a small arm or tappet piece *m, fig.* 427, is fixed, standing at right angles to the face of the forked frame of the holder H. Those tappets, as the endless chain conducts the holders along at certain periods, come in contact with stationary pins or wipers *n n*, fixed to the guide rails *o*, on which the chain C slides; and these wipers acting against the tappets as they pass, cause the holders to be turned round at those periods for the purpose of bringing the reverse side of the strick of flax on to the heckle points.

Let it now be supposed, that all the holders connected to the endless chain have been furnished with stricks of flax, or other material to be heckled, and that the barrels A A are put in motion in the way described, revolving in the direction of the arrows shown in *fig.* 427. A pinion on the end of the axles of one of the barrels A will drive a train of toothed gear, J K L M and N, on the axle of the latter, of which there is a bevelled pinion taking into a bevelled wheel, turning horizontally at the lower end of the perpendicular shaft of one of the chain pulleys. It will hence be perceived, that as the barrels go round, such rotatory motion will be communicated to the pulley B, as will cause it to drive the chain C forward, and by that means conduct the several stricks of flax progressively along the barrel.

When each successive holder, with its strick of flax or other material, is brought to the part *z, fig.* 426, the fibres come in contact with the rotatory barrel, and first strike upon the series of coarse heckles *a a*, placed upon an inclined or conical surface of the barrel, by which means the lower ends of the flax in each strick are first acted upon; and as it advances, the upper part, and ultimately the whole length of the long fibres of the suspended strick, are gradually brought on to the heckles, which progressive operation prevents the long fibres from being broken, and causes a smaller quantity of tow to be produced than is usually taken off in any of the ordinary modes of heckling.

After the strick of flax or other material has been carried by the travelling chain past the first inclined or conical surface *a*, of the heckling barrel, it then comes upon the cylindrical part, *b*, of the barrel, which is also furnished with coarse heckles that penetrate and comb down the whole pendent lengths of the fibres. But in order that both sides of the strick of flax may be equally operated upon, the holder is now to be turned round upon its pin or pivot, which movement is effected by one arm of the lever or tappet *m*, (as the carrying chain moves onward), coming against the stationary pin or wiper *n*, which changes the position of the holder, as shown at *p*, in the horizontal view *fig.* 426.

The under part of the guide rail *o*, upon which the chain slides, is at this part cut away, for the purpose of allowing the holder to turn round horizontally; and a pin or projection at the under side of the guide rail, as the chain continues moving, acts against

the side of the carrier frame, and forces it into a position parallel with the chain. The other side of the strick of flax is by these means brought on to the heckles of the second inclined or conical surface of the barrel at *c;* and the travelling chain proceeding onward, the fibres of the material are in succession passed over and combed by the heckles of increasing fineness, *d, e,* and *f,* on the cylindrical part of the revolving barrel, until the strick having arrived at the second wiper *n,* the frame or holder is at *q,* turned round as before, and the reverse side of the strick, or that first operated upon by the heckles *a* and *b,* is brought progressively on to the heckles of increasing fineness, *g, h,* and *i;* and having passed the last series of rotatory heckles, the holders are in succession to be removed from the machine, the material having been sufficiently dressed.

The clamps of the holders are now opened by the attendant, and the stricks of flax or other material are taken out, and again placed between the clamps in reversed positions, in order that the other ends of the fibres may be operated upon. The clamps, with the stricks, are then suspended again in the holders, the uncombed ends of the fibres hanging down upon the heckle barrel.

In order to avoid interrupting the continual operation of the machine, it is proposed that the strick, on its second introduction, shall be placed in the holders on the opposite side at *y,* which is one of the reasons for constructing a double machine, and the strick being thence carried along by the travelling endless chain in the way already described, the fibres will be first brought under the operation of the coarse heckles on the inclined or conical surface of the second revolving barrel, and then of the other heckles increasing in fineness on the cylindrical part of the barrel, until having reached the end, as in the former instance, the fibres of the flax may be considered to be sufficiently dressed, and may then be withdrawn.

It may be necessary here to remark, that as different kinds and qualities of material will require different degrees of working by the heckles, this can be effected by varying the comparative speeds of the travelling holders and the heckle barrels. These comparative speeds, it will be perceived, depend upon the diameters of the wheels and pinions by which the pulley *n* is driven from the rotation of the heckle barrel. These wheels and pinions are therefore intended to be removed and changed for others of different diameters, as circumstances may require. It will be perceived that the faster the stricks travel through the machine compared to the rotatory speed of the heckle barrels, so much the less will the material be acted upon by the rotatory heckles; but as different qualities of material must be differently operated upon, according to circumstances, it is impossible to set out any definite speeds or proportions of speed: that will, however, be readily perceived by competent workmen when working at the machine.

In the process of opening the fibres of the material by the rotatory heckles, a quantity of short or loose fibres, as tow, will be taken off the stricks by the heckle points, and will remain adhering to the barrel between the points of the heckles: in order, therefore, to remove this tow or other loose entangled materials from the heckles, several series of brushes, or blocks, with bristles, are affixed longitudinally to rotatory barrels q q.

These brush barrels are mounted parallel to the heckle barrels upon axles, supported in plummer blocks affixed to brackets extending from the end frames of the machine. Those parts of the brush barrels which are opposite to the cylindrical portions of the heckle barrel are cylindrical, and those parts which are opposite to the bevels are contrabevelled, or made as frustrums of cones reversed, or in an opposite angle, as *r, s,* so as to run parallel to the inclined surfaces of the heckle barrels *a* and *c.*

Upon the periphery of these barrels q q, ribs or blocks, with bristles or brushes, are fixed longitudinally, at suitable distances apart, the bristles all standing radially from the axle, and taking into the points of the heckles.

Rotatory motions are given to the brush barrels q q, by bands passing from the riggers at g, over pulleys r r, fixed at the end of each of the axles of the brush barrels. Hence, it will be perceived that the barrels q q will revolve in opposite directions to the heckle barrels, and with sufficient speed to enable the brushes to pass through between the points of the heckles, and, in so doing, to remove the tow or other loose matter therefrom.

The tow or other loose fibrous material collected upon the brushes is transferred thence on to wire cards placed round the periphery of the barrels s s, which barrels are mounted upon axles parallel to the brush rollers, and turn in plummer blocks upon brackets, extending from the end frames of the machine.

These barrels are cylindrical, and covered with sheets of wire cards at those parts which are opposite to the cylindrical portions of the brush barrels, but those portions of the barrel s which are opposite to the bevelled points, *r* and *s,* of the brush barrels, are bevelled or made conical at *t u,* to fit or correspond with the inclined surfaces *r* and *s;* these are covered with sheets of wire card also.

Rotatory motions are communicated to the card barrels **s s,** by bands from the pulley

r, fixed on to the side of the toothed wheel M (see *fig.* 427), which band drives similar pulleys v v, mounted upon studs fixed in the end frame. Upon the side of each of these pulleys v v, a pinion *l* is fixed, which pinion takes into the teeth of the wheel w, on the end of the axle of each of the card barrels s s; by which means such slow motions are given to the barrels s, as will allow the brushes of the barrels Q to comb off and deposite the tow or other fibrous material upon the wire cards as they revolve, and from whence it is to be removed by a doffing comb, and let fall into any convenient receptacle below, in the same way as in ordinary carding engines.

The doffing combs, x x x, are formed to the shape of the card barrels, and are attached to straight bars extending along the machine on both sides, which are supported at their extremities by levers Y Y, vibrating upon fulcrum pivots at *w w*. To these levers perpendicular rods, z z, are connected by joints, and the lower end of each of these rods is attached to an eccentric disc, roller, or crank, *x x*, on the axle of the brush barrel; whence it will be perceived that by the rotation of the eccentrics *x*, the levers Y will be made to vibrate and strike off, or doff the tow or other material from the card barrels, in a similar manner to the operations of the doffing comb of an ordinary carding engine.

Mr. Evans's patent improvements in machinery for preparing and dressing flax and hemp apply, first, to the operation of scutching, swingling, or beating away the boom or woody particles of the rind which covers the flax, or hemp, in its rough state; and, secondly, to the subsequent operation of heckling, combing, or opening of the fibres of the material preparatory to spinning it into yarns.

Fig. 428 represents the scutching or swingling machine, in different positions.

429   428
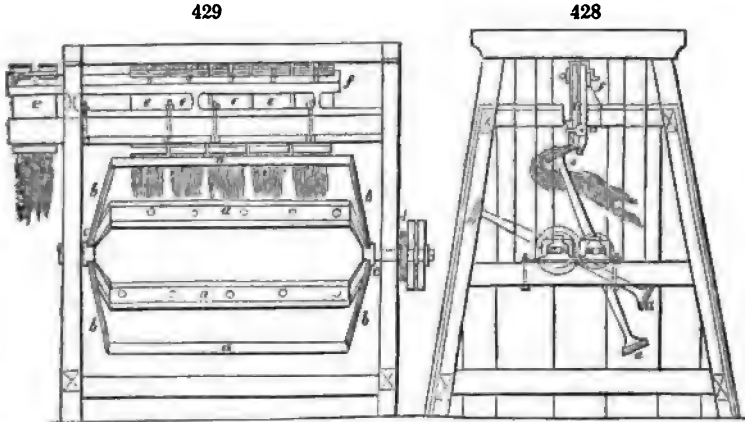
Fig. 428 is an end view of the machine in operation; *fig.* 429 is a front view of the same. The essential parts of the machine, and those in which the invention especially consists, are two pairs of revolving beaters or scutchers, each formed by long ribs or blades mounted upon arms. The blades of the beaters, a a, may be made of ribs of hard wood, or other suitable material, broad but thin, and slightly rounded on their edges, to prevent their cutting the fibres of the flax or hemp when they strike it. The two blades are placed parallel to each other, and mounted upon a hexagonal frame, the arms b b inclining or forming obtuse angles with the blades, and from the middle of the arms short axles, c c, extend, upon which the beaters revolve.

The axles of both pairs of beaters are mounted in plummer boxes, bearing upon horizontal rails at the ends of the machine, as shown in *fig.* 428, and are at such distance apart as will allow of the arms and the beaters of each pair passing alternately within those of the other pair as they revolve in opposite directions, which they are enabled to do without coming in contact, in consequence of the inclination of the arms.

On the axle at one end of each pair of beaters a toothed wheel, d, is affixed, and these wheels being of similar diameters, and taking into each other, cause the beaters to revolve with similar speed in opposite directions, rotatory motion being given to them by a band and rigger fixed upon one of the axles; and in order that the beaters in revolving may not come in contact as they pass, the positions of the two pairs are so arranged that the blades of one shall be in a perpendicular situation, while those of the other are horizontal.

The rind of the flax or hemp having been previously broken by any of the ordinary modes of performing that operation, small bunches or stricks of the material are spread out, and their ends confined between the jaws of clamps or holders.

These clamps or holders differ considerably from the clamps which are commonly used. I shall therefore particularly describe their construction, before showing them in operation. *Figs.* 430 and 431 are views of the clamp in two different positions; *a* and *b*
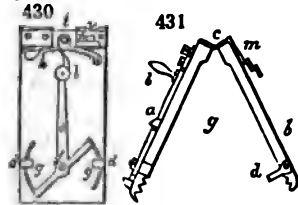
are two boards united together by a hinge, *c*, at top, which of course allows them to shut and open. The lower parts, forming the jaws of the clamps, are made with teeth or indentations, between which parts the ends of the flax or hemp are securely held when the clamps are brought together; *d d* are two pieces projecting from the board *b*, at the end of each of which is an eye shown by dots, and at the back of the board *a* (see *fig.* 430), there is a double armed lever, *e*, turning upon a fixed pin, *f*, which lever carries two circular wedges, *g g*. These wedges pass into the eyes of the pieces *d d*, when the clamps are closed and hold them fast. There is a segment ratchet *h*, at the upper part of the board *a*, which turns upon a stud, *i*, and is pressed downward by a spring, *k*. This ratchet receives the end of the lever *e*, and consequently keeps the circular wedges firm in the eyes, which hold the clamps securely together, and prevent their opening by the shaking of the machine.

When it is required to open the clamps, the ratchet *h* must be raised, and the lever *e* pushed aside by its handle *l*, which draws the circular wedges *f* from the eyes of the pieces *d d*, and the boards of the clamps immediately separate. For the convenience of suspending the holders in the machines, a piece of sheet iron, *m*, is bent at right angles, and fastened to the back of the board *b*, as seen in *fig.* 431, forming a groove by means of which the holders are enabled to slide into the machine and hang there.

These clamps or holders are, when charged with the material, placed in the scutching machine, as shown at *e e e*, in *figs.* 428 and 429, bearing upon the edge-rail or bar *f*. The beaters are now made to revolve in the manner already described, by which the edges of the blades will strike against the pendent stricks of flax or hemp alternately on each side, and beat off, scutch, or swingle the boom from the material, and render it fit for the operation of heckling which is to follow.

The whole machine is incased with boards, to prevent the inconvenience arising from dust, and an apparatus might be adapted with a blower to conduct away the dust created by the machine, and to discharge it out of the building.

In introducing these stricks of flax or hemp into the machine, the holder is placed upon the projecting end of the bar or edge-rail *f*, and is thence slidden into the machine; and after the material has been sufficiently scutched or swingled, the holders, with the stricks, are removed through the top of the machine, and others successively introduced at the end, and pushed along the rail.
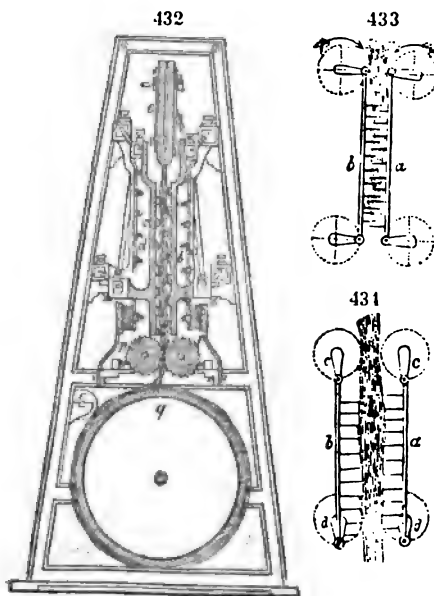
If, however, it should be thought desirable, the stricks may be progressively carried through the scutching machine, and delivered into a similar edge-rail in the heckling machine, there to be operated upon in the way about to be described, by which means the whole process of scutching and heckling may go on without interruption.

Fig. 432 represents the heckling or combing machine by which the fibres of the material are to be opened, and the tow removed. It is a transverse section, taken nearly through the middle, in a vertical direction. Perpendicular standards form the ends of the machine, which are connected together by longitudinal rods or bars secured by nuts. The heckle points intended to act upon the flax are mounted in the frames *a, b, c,* and *d,* and the stricks of flax held in the clamps *e e e,* as described, are suspended from the bar or edge-rail, extending through the machine.

:r to render the principles of this machine and its mode of working evident, it
esirable to show in an abstract form the manner in which the heckles are brought
ation upon the flax, and for this purpose two diagrams are delineated in *figs.*

e two sets of combs or heckle points be mounted upon frames *a* and *b*, as in
ires, each frame being moveable by means of cranks *c, c,* and *d, d,* connected in
ner that they both turn with the same speed in opposite directions, it is evident
y part of the frames and combs will move in circles corresponding to those de-
y the cranks; the points of the combs travelling in the directions of the arrows,
rcles represented by dots.
: this movement, whilst performing the first descending quarter of the circle, the
ing the frames together as in *fig.* 433. They begin after this to separate in de-
:he second descending quarter, and come to the position *fig.* 434, when, continu-
rolve, they move further from each other in describing the first ascending quarter
rcle, and arrive at the position where the distance is the greatest; lastly, they
the second ascending quarter returning to the third position. If, therefore, a
flax be suspended between the two sets of combs as in *fig.* 433, and the rotatory
e continued for a sufficient length of time, the flax will be combed in the whole
hich is submitted to the actions of the combs, although the points severally have
ated in a very small space.
system of combs or heckles would make a very good and simple heckling engine,
: not for the inconvenience experienced by the points dragging some of the fibres
n when withdrawing from the flax, which would produce a great waste of mate-
l to obviate this it would be necessary to introduce some contrivance for clearing
s, which must be attended with considerable complication. The plan, however,
esent improved engine, affords the means of producing the same effect by more
d efficient means.
arc two series of combs, see *fig.* 435, attached to two moveable frames repre-

436   437

sented at *a* and *b.* Each frame is formed
by vertical bars *a b,* with lateral branches
or arms, which carry the heckle points.
The branches or arms are parallel, and at
equal distances apart, but fixed in such
positions in each frame that they may oc-
cupy the intervening space when the frames
are brought together, as *fig.* 436. The
frames are put in motion by means of re-
volving cranks to which they are attached,
as shown in *fig.* 436, and when the cranks
turn upon their axes, the branches of one
frame pass between those of the other
without touching. This forms what may
be called a set of combs; but one of the
improved machines contains two such sets,
s of the combs of one set being opposed to the points of the combs in the other set.
ay in which the series of combs that compose one set act upon the flax, is shown
le view *fig.* 435. When the cranks are nearly vertical, the points of both frames
from the flax, but as the cranks move round in the direction of the arrows, the
ome into another position, and it is then that the points or heckles of one of the
, begin to penetrate the flax, and descending they comb or divide its fibres. The
of the cranks continuing, the two frames *a* and *b* come into the position shown
35, the points of the frame *a,* withdrawing from the flax, and those of the frame
ching and pushing the fibres off from the former, which are now combed by the
ig stroke of the points.
hence be perceived that as the combs of the frame *a* and *b,* respectively advance,
push forward the whole of the strick of flax, and render it impossible for the
be raised and entangled, as each frame in advancing clears the fibres from the
hich preceded it.
le set, however, of such combs or heckles acting only on one side of the flax,
ut imperfectly perform the operation of opening its fibres; it is therefore
:, in order to accomplish the desired object in the most effectual way, that two
of combs or heckles should be brought to act on opposite sides of the strick of
ch may be done in the manner shown in the figures. The cranks of the two
sets of comb-frames or heckles *a b,* and *c d,* are connected by a pair of toothed
f, as *fig.* 437, or by four toothed wheels, by which the heckles are actuated at
: two sets moving in opposite directions, but with similar speeds, and the
or heckling of the material will go on in the way shown in the figure last
.

Thus far I have considered only two frames of combs or heckles constituting a set, as acting upon each side of the strick of flax ; but in order to perform a greater quantity of work, several sets may be mounted in one machine, working alongside of each other, extending over the breadth of the machine. The combs may then be supported upon three frames, of which the middle one may have branches or arms extending upon both sides, and the other two frames branches extending inwards only. To drive the frames so arranged they must be connected to treble cranks.

Such is the principle of the improved machine for combing or heckling, exhibited in the several figures of which I now proceed to describe the particular construction. The machine or engine, *fig.* 432, has four sets of combs, acting both at the back and front of the flax ; *a b* are the front set of combs, and *c d* the back set of combs ; *e e e*, are the clamps holding the stricks of flax previously scutched, which clamps hang upon the edge-rail. The comb frames are attached at top and bottom to the cranks *g g*, which are all connected by toothed gear, and driven by a band and rigger.

The combs or heckles being put in motion in the way described, act upon the suspended stricks of flax, and upon their fibres, as explained; which stricks are progressively conducted through the machine by their clamps sliding upon the edge-rail through the agency of the endless chain, to which the clamps are severally attached, by a hook falling into one of the links. The chain is driven by a spur wheel upon the axle of a bevel wheel, which receives a slow rotatory motion through a bevel pinion on the axis of a similar wheel, actuated by another pinion on the end of the upper crank axle. By these means, clamps, with the stricks of flax placed on the edge-rail, are slowly carried through the machine, when the flax will be gradually acted upon first by heckle points of a coarse kind, set wide apart, and ultimately by finer points set near together; after which, the clamp with the strick of flax is discharged from the machine, at the reverse end of the edge-rail. But should the workman neglect to remove the holder or clamp, when it arrives at the end of the rail, the machine would be stopped by means of a jointed lever, having a fork at its end, which pushes the band from the fast rigger on to the loose one, and throws off the driving power.

As the combs or heckles, in acting upon the flax to divide its fibres, tear parts of the fibres, and reduce them into tow, the downward motion of the heckles brings the tow with them out of the flax, which is deposited between two fluted rollers *p p, fig.* 432, and is by them conducted down to the large drum *q*, where it becomes lapped in two endless sheets round the periphery of the drum; the one of coarse tow, the other of fine, the adhesion being assisted by a pressing roller *r ;* and when a quantity of the tow has been thus accumulated round the periphery of the drum, it may be removed thence by cutting it off in sheets. The fluted rollers, and also the large drum, are driven by gear bands.

After the strick of flax has been thus carried through the scutching machine or the heckling machine, the jaws of the clamps are to be opened, the ends of the flax reversed, and the strick again confined in the clamps, so that the other end of the strick may be operated upon in a similar way. In order to prevent any part of the flax from attaching itself to the branches of the moveable frames, each frame is furnished with a shield or guard of polished iron or brass plate, which covers a part of the combs and the heads of the screws by which they are fixed to the branches. When the plate metal is bent into the form of a shield, it is slipped on to the branches of the heckle frames, and is sufficiently elastic to hold fast.

But it is to be observed, that the edges of the shields are to vary in the extent of their projection according to the situation in which they are to be placed; those which are to shield the upper branches of heckles are to project but little, so as to leave the points uncovered and free to enter the strick of flax; but the shields of the lower heckles are to project considerably over the points, to prevent them from penetrating too far into the fibres, which is so contrived for the purpose of facilitating the falling of the tow, which would otherwise be with difficulty removed from the lower combs, were it thrust upon the whole length of the points.

It being advantageous that each strick of flax should be combed near the lower extremities before the middle is acted upon, it is necessary, in order to obtain this effect, to remove some of the points of the combs in the upper branches. By these means, the operation of the heckles upon the flax begins and proceeds gradually, and ceases at the opposite extremity of the machine in the same gradual way, which is very advantageous in clearing completely the flax from the tow.

IV. *Flax-spinning.*—If we compare flax with other spinning materials, such as wool and cotton, we shall find it to possess several characteristic properties. While cotton and wool are presented by nature in the form of insulated fibres, the former requiring merely to be separated from its seeds, and the latter to be purified from dirt and grease before being delivered to the spinner, flax must have its filaments separated from each

other by tedious and painful treatment. In reference to the spinning and the subsequent operations, the following properties of flax are influential and important :—

1. The considerable length of the fibres, which renders it difficult, on the one hand, to form a fine, level, regular thread, on the other, gives the yarn a considerably greater tenacity, so that it cannot be broken by pulling out the threads from each other, but by tearing them across.

2. The smooth and slim structure of the filaments, which gives to linen its peculiar polished aspect, and feel so different from cotton, and especially from woollen stuffs, unless when disguised by dressing. The fibres of flax have no mutual entanglement, whereby one can draw out another as with wool, and they must therefore be made adhesive by moisture. This wetting of the fibres renders them more pliant and easier to twist together.

3. The small degree of elasticity, by which the simple fibres can be stretched only one twenty-fifth of their natural length before they break, while sheep's wool will stretch from one fourth to one half before it gives way.

Good flax should have a bright silver gray or yellowish color (inclining neither to green nor black); it should be long, fine, soft, and glistening, somewhat like silk, and contain no broad tape-like portions, from undissevered filaments. Tow differs from flax in having shorter fibres, of very unequal length, and more or less entangled. Hemp agrees in its properties essentially with flax, and must be similarly treated in the spinning processes.

The manufacture of linen and hemp yarn, and the tow of either, may be effected by different processes; by the distaff, the hand-wheel, and spinning machinery. It will be unnecessary to occupy the pages of this volume with a description of the first two well known domestic employments. I shall therefore proceed directly to describe the last method, or

Spinning of Flax by Machinery. —This branch of manufacture has been much more recently brought to a practical state than the spinning of cotton and wool by machines, of which the cause must be sought for in the nature of flax as above described. The first attempts at the machine spinning of flax, went upon the principle of cutting the filaments into short fragments before beginning the operation. But in this way the most valuable property of linen yarn, its cohesive force, was greatly impaired; or these attempts were restricted to the spinning of tow, which on account of its short and somewhat tortuous fibres, could be treated like cotton, especially after it had been further torn by the carding engine. The first tolerably good results with machinery seem to have been obtained by the brothers Girard at Paris, about the year 1810. But the French have never carried the apparatus to any great practical perfection. The towns of Leeds in Yorkshire, of Dundee in Scotland, and Belfast in Ireland, have the merit of bringing the spinning of flax by machines into a state of perfection little short of that for which the cotton trade has been so long celebrated.

For machine spinning, the flax is sometimes heckled by hand, and sometimes by machinery. The series of operations is the following : —

1. The heckling.
2. The conversion of the flax into a band of parallel rectilinear filaments, which forms the foundation of the future yarn.
3. The formation of a sliver from the riband, by drawing it out into a narrower range of filaments.
4. The coarse spinning, by twisting the sliver into a coarse and loose thread.
5. The fine spinning, by the simultaneous extension and twisting of that coarse thread.

The spinning of tow requires a different treatment: we shall first treat of the heckling of flax by machines; and secondly, of the mechanical spinning of flax. The mechanical carding and spinning of tow are very similar to those of cotton; which see. Though machine heckling be far from perfect, yet the tow it throws off can be spun into very good yarn by machines, while it would afford very indifferent yarn to the hand spinner.

All heckle machines have this common property, that the flax is not drawn through them, as in working by hand, but, on the contrary, the system of heckles is moved through the flax properly suspended or laid. Differences exist in the shape, arrangement, and movements of the heckles, as also in regard to the means by which the adhering tow is removed from them. The simplest and most common construction is to place the heckles upon the surface of a horizontal cylinder, while the flax is held either by mechanical means or by the hand during its exposure to the heckle points. Many machines have been made upon this principle. It is proper in this case to set the heckle teeth obliquely in the direction in which the cylinder turns, whereby they penetrate the fibres in a more parallel line, effect their separation more easily, and cause less waste in torn filaments. To conduct the flax upon the cylinders, two horizontal fluted rollers of iron are employed, which can be so modified in a moment by a lever as to present the flax more or less to the heckling mechanism. The operator seizes a tress lock of

flax with her hand and introduces it between the fluted rollers, so that the tips on which the operation must begin, reach the heckles first, and by degrees the advancing flax gets heckled through two thirds or three fourths of its length, after which the tress or strick is turned, and its other end is subjected to the same process. By its somewhat rapid revolution the heckle cylinder creates a current of air which not only carries away the heavy particles, but also spreads out the flax like a sheaf of corn upon the spikes, effecting the same object as is done by the dexterous swing of the hand. The tow collects betwixt the teeth of the heckle, and may, when its quantity has become considerable, be removed in the form of a flock of parallel layers.

The essential parts of such a construction will be understood from *fig.* 438, though the fluted rollers are absent. The flax *a*, *b*, is held by the hand, or in a kind of clamp. The cylinder is partly covered with a curvilinear plate of iron *c*, *d*, which serves to sustain the flax, and to guide it in circular tresses round the periphery of the heckle. At the beginning it is placed near *b*, when the tips of the flax are only presented to the heckle; during the working the shield is continually drawn back in the direction from *d* to *c*, and thus lets the operation be performed upon the remaining part of the flax.
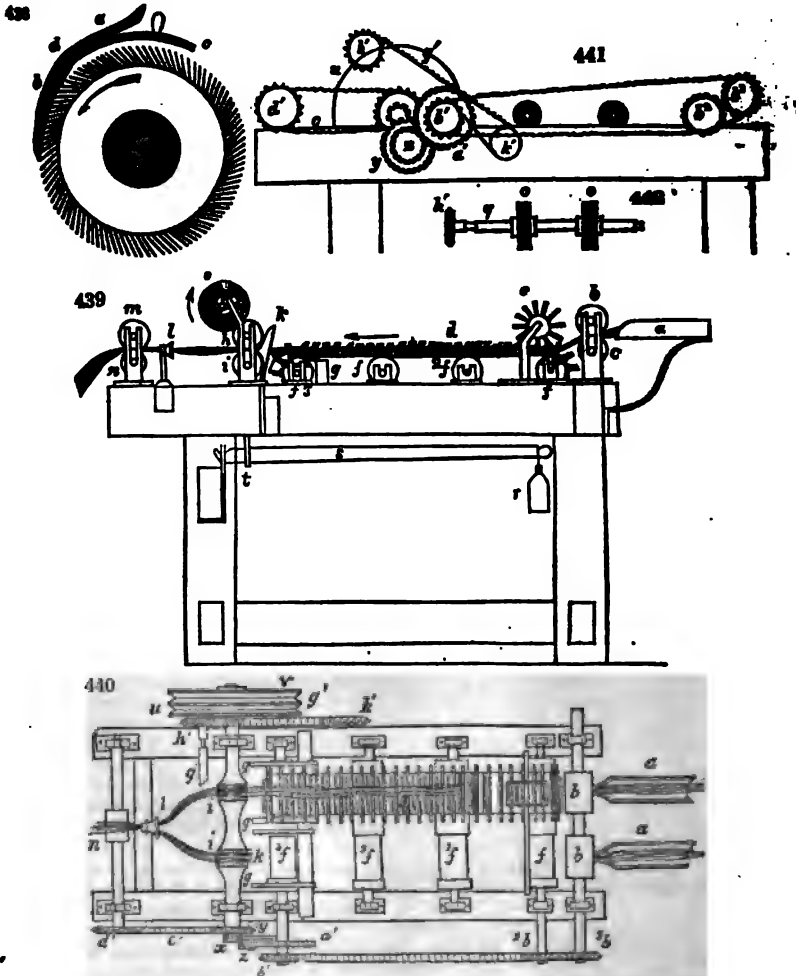
First operation; the conversion of flax into ribands or slivers.—This is effected by subjecting the flax to a series of advancing gills or heckle-teeth, and at the same time drawing out its fibres by means of rollers. *Figs.* 439, 440, 441, show the outline of the con-

machine for this purpose. Here two rows of heckles are placed alongside though only one of them be shown in the ground plan, *fig.* 440, in order to ·ts beneath the other to be seen. The flax is placed in the sheet iron by laying down one handful after another, so that the points of the second o only the middle of the first, and thus preserve a uniformity of thickness . This process is necessary, since, as every one knows, the heckled stricks .ck in the middle, and thin at the ends. The flax being introduced between nd *c*, is drawn out by their agency, and at the same time subdivided by the ween whose teeth the pins of the roller *e* press it down. At the rollers .ed from the heckles by the transverse bars which rise from the springs *g*, is seized by the rollers *h i*, and drawn again. A little beyond these rollers, h a funnel *l*, in order to gather the fibres together; in front of these rollers m both rows of heckles are united, and proceed in one riband through that s funnel; the rollers *m n* extend this riband, pressing it gently together, it fall into a tin can. The union of the two slivers contributes to the ice the irregular thicknesses are thereby compensated. The diameter of ı equal to that of each of the cylinders *f, f1, f2, f3*; and the whole five ial velocity. The same correspondence exists between the rollers *n* and *i*. er of flax is not stretched either by its passage from *e*, upon the heckles, *i* and *n*, but solely in passing from the heckles to the rollers *i h*. The of this machine do not stand perpendicularly, but are bent somewhat o as to retain the flax more firmly. The revolving cylindrical brush *o*, ·and a little in front of the pressing roller *h*, in order to take off all the ax adhering to their circumference, and to toss them onwards where they ite with the slivers. For the sake of perspicuity, the rollers *h*, and those ft out in *fig.* 440, but the latter are particularly shown in *fig.* 442, while a ir axis *q*, is however shown in *fig.* 440. The pressure of the cylinder *h*, der *i*, is produced by the weight *r, fig.* 439, which hangs upon the lever *s*; ı down at *t*, a vertical rod, whose upper hook-shaped end embraces the axis ıddle of its length.

cipal operation; the formation of rovings.—Mr. Wordsworth's improve-ıinery for preparing, drawing, and roving flax, hemp, wool, and other fibrous ınsists in a novel contrivance or mechanism to be adapted to the machine led the gill, employed for preparing, drawing, and roving flax and hemp, ıng and spinning long wool; which improvements allow the points of the :kles to continue longer in operation than in the ordinary construction of ł the heckle points to be withdrawn from the fibres at the end of the stroke ıssibility of their drawing the fibres down with them.

r of effecting this object will be seen by reference to the several figures which exhibit a gill on this improved plan in different views. *Fig.* 443 is a plan or horizontal view, exhibiting the upper surface of the machine; and *fig.* 441 is a longitudinal section taken through the middle of the machine: *fig.* 445 is a representation of the front of the machine, but in which several parts have been removed to show the action of the heckles more perfectly.

The several heckles *a a a* are formed by a series of needles or heckle points set into a metal bar, as represented on an enlarged scale in *figs.* 446 and 447. These bars are each of them suspended in a frame or carriage

n two views at *figs.* 448 and 449), by means of double jointed levers *c c*, ositions, at *figs.* 450 and 451; the heckle bar, its levers and carriage or hown put together in *figs.* 452 and 453. ıeckles are in operation, the points are raised, as in *fig.* 445; but when drawn from the fibres, then the points are sunk down into the carrying . 453. positions of the heckles are produced by the knobs or parts *d*, that project
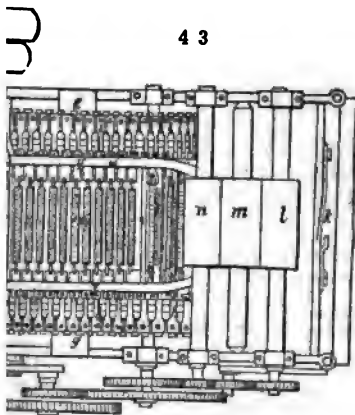
from the jointed levers c, acting against the edges of guide bars, which will be explained in describing the operations of the machine.
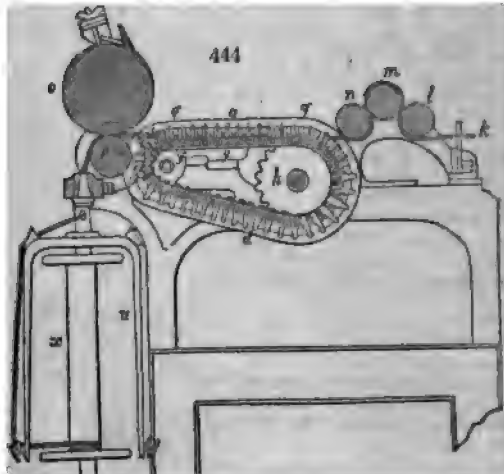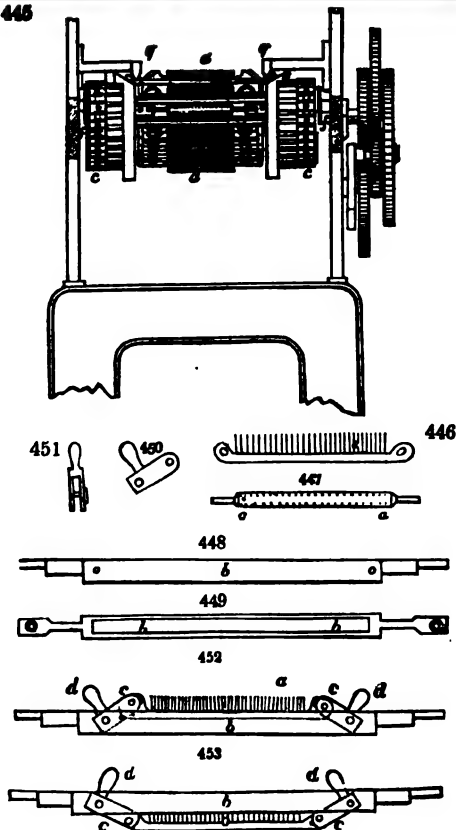
The several heckles are adapted and made to work in the machine by attaching the ends of the respective frames or carriages b, to travelling endless chains $e, e,$ seen in *figs.* 443, 444, and 445. These endless chains pass over fluted guide rollers f f, seen best in *figs.* 444 and 445, and over horizontal bars g g, seen best in *fig.* 443 and 444. The chains with the heckles are driven through the machine by rotatory spur wheels h h; see *figs.* 443 and 444, the teeth of which take into the spaces between the cylindrical parts of the several heckle carriages b b, and consequently drive the heckles forward; and these spur wheels are actuated by a train of toothed gear from the first driving shaft i, which gives motion to all the operative parts of the machine.

If flax, hemp, long wool, or other fibrous material, be passed into the machine at the back part by a feeding cloth or creeper through a guide k, best seen in *figs.* 443 and 444, and be conducted under and over the feeding rollers l, m, and n, and over the heckles a a a to the drawing rollers o and p, and thence to the flier and bobbin, or to a receiving can, the fibres will be opened in their progress, and combed by the points of the heckles entering into and separating the fibres, the material being drawn by a different speed to that with which the heckles travel.

This operation of preparing, drawing, and roving flax and hemp, and the general construction of a machine of this kind being well understood, it is not necessary to explain its details, excepting as respects those parts which constitute the present improvements.

It will be perceived, by reference to *figs.* 443 and 444, that the knobs d, which project from the jointed levers c, as they travel along the machine, bear against the outer edges of the two fixed guide bars q q that extend along the top of the machine above

s, which keep the heckle points raised, as in *fig.* 451. This will also be very
seen in the front view of the machine, *fig.* 445, where the upper heckle bar *a*
n its carriage *b*, by the knobs *d d* bearing against the outer edges of these
s, *q q*. But when the endless chains *e e*, which support and conduct the frames
es of the heckles, have advanced the heckle points to within a very little dis-
he drawing rollers (see *fig.* 444), then the knob *d* of the jointed levers at each
: heckle bar passes the ends of the guide bars *q q*, and they immediately come
with two inclined planes, *r r*, seen in *figs.* 443 and 444, which instantly depress
c, and consequently cause the heckle bar *a*, with its points, to descend in the
:arriage *b*, withdrawing the points from the fibres of the material almost in a
ular direction.

ckles that have become thus depressed pass with their carriages by the travers-
endless chains along the under part of the machine, and when they arrive at
and begin to rise, the guide bars *q q*, being at their commencement slightly bent,
he knobs *b* of the levers *c* until they are forced back into the positions first
whereby the heckle points are raised, as they come to the upper part of the
nto effective operation. The fibres of material operated upon, after passing
ıe drawing process between the rollers, may be roved, twisted, or spun, by the
nt of a bobbin and flier, as shown *fig.* 444, or may be delivered into a can, to
twisted, or spun, by other machinery, by substituting a pair of conducting
tead of the bobbin and flier, which shall conduct the sliver of material into a
low.

cent of the heckles *a* into their frames *b*, by the falling of the levers *c c*, pre-
possibility of the fibres of the material operated upon being carried down
machine by the points, as frequently happens in gill machines of the ordinary
ɔn; and this mode of mounting the heckles and traversing them with the
of the guide bars *q q*, and inclined planes *r r*, allows the heckle points to be
uch nearer to the drawing rollers *o p*, by means of the metal bars in which
· points or needles are set, falling below the centre of the endless chain *e e*,
in *figs.* 443 and 444, and thereby affords the means of preparing, drawing, and
·ious qualities of flax, hemp, wool, and other fibrous materials, particularly
ıve a much shorter staple than any fibrous materials hitherto operated upon in
nery.

· most ingenious and effective improvement made of late years in the flax
nachinery, is that patented by Messrs. Westley and Lawson, in August, 1833,
then introduced into practice with great advantage. It applies to the *gill* or
ı employed for opening, straightening, and separating the fibres of flax,
l long wool, in the operation of slivering. The peculiar feature here is a
driving the heckle bars through the gill machine by means of perpetual
worm shafts, instead of by chains and spur wheels, as in the former con-

:kle bars which lie across the machine are, by the present patentees, supported
ıds by fixed horizontal guide rails, on which they slide, while the extremities
:kle bars are inserted in the helical grooves of the worm shafts, which are
ıorizontal positions at the sides of the machine; and hence the rotatory motions
ıese screw shafts cause the heckle bars to be driven along the guide rails with
simultaneous movement.

kle bars having performed their usual office, that is, having combed and sepa-
fibres of the material as they move onward, are at the front part of the
epressed and put out of operation by means of rotatory cams; and by the assist-
iide levers, each heckle bar, when it arrives at the end of the upper horizontal
is conducted down to the lower horizontal guide rails, where the extremities
ıb-bars falling into the helical grooves of a lower pair of worm shafts, revolv-
ıpposite direction to the former, thereby give the heckle bars a retrograde
. When they arrive at the back end of their horizontal guide rails, they are,
rotatory cams, raised again to the upper horizontal guide rails, which coming
rith the upper worm shafts, are moved onwards as at first.

means a succession of heckles is continually advancing upon the upper guide
ıg their points in constant operation between the fibres of the textile materials,
· vertical position is secured during their whole course.

l is a horizontal representation of a gill machine, showing the present im-
ı; but some of the upper portions of the machine are removed, to let the work-
e seen more clearly. *Fig.* 455 is a side view of the gill; and *fig.* 456 a verti-
taken longitudinally. The driving rigger or pulley *a* is fixed upon the front
mmonly called the drawing roller, because when pressed upon by the upper
ler *c*, it draws out the fibres between them. The rollers *d, e, f,* are the ordi-
ɔr holding rollers, for retaining the fibres, while they suffer powerful traction

by the rollers *b, c,* over the needles or points of the heckle bars. The upper guide rail above mentioned, upon which the heckle bars slide, is shown at *g,* in *fig.* 456, and the

454
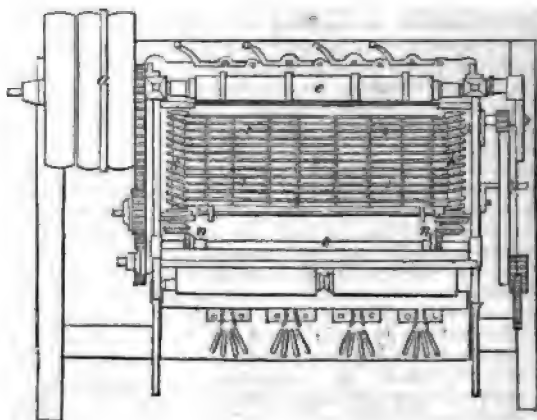
lower guide rail at *h;* the series of heckle bars with their needles are represented at *i, i, i, i, i, i;* the upper worm shafts *k, k,* are mounted in brackets made fast to the sides of the frame; a similar pair of worm shafts *l,* being mounted in like manner below. These worm shafts *k* and *l,* on each side are connected together by toothed wheels *m,* and upon the axles of the lower worm shafts, bevelled pinions *n* are fixed, which take into corresponding bevel pinions on the transverse shaft or axle *o.* This shaft *o,* being connected by a train of toothed wheel work with the axle of the drawing roller *b,* as shown in *figs.* 454 and 455, the rotation of the roller *b,* causes the shaft *o* to turn also, and the bevel gear *n* and *o,* produces the rotatory motion of the worm shafts *k* and *l,* which turn in contrary directions.
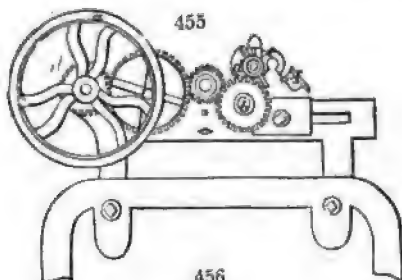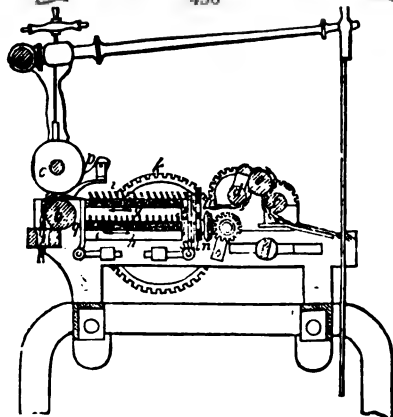
455

It will be seen, from *fig.* 454, that the ends of the heckle bars *i,* have nibs or projections which fall into the grooves of the screw or worm shaft, and that being supported below, upon their guide rails, as the worm-shafts *k k* revolve, the upper range of heckle bars will be progressively advanced towards the front part of the machine. By referring to *fig.* 456 it will be perceived, that as each heckle bar arrives at the front end of the guide rail *g,* a finger *p,* called a tappet or cam, on the shaft *k,* strikes it down to the lower guide rails *h;* and, in order that its descent may be truly vertical, weighted levers *q q,* in front, are made to press against the face of the heckle bar as it descends. This

456

bar having now arrived at the lower guide rails *h,* lets fall its nibs into the grooves of the lower worm shafts *l,* by whose rotation the heckle bar is made to retrograde, or return towards the back of the machine. When the heckle bar has reached the hinder end of the guide rail *h,* a finger or tappet, *r,* on the lower worm-shaft, comes under it and raises the heckle bar, guided by the back-weighted levers *s,* as shown in *fig.* 456, till it is elevated to the level of the upper guide rail *g;* when the threads of the upper worm shafts take hold of its nibs as before, and conduct it forward upon the guide rail in the

already described. Thus the continued rotation of the worm shafts *k k* and *l l*,
es the whole series of heckle bars to travel along the guide rails, and the tappets
d *r*, by alternately depressing and raising them at the ends of the said rails, cause
ι to move in a regular circuit, yet so as to preserve their verticality.

ιe claim made under this patent is for every mode in which screw or worm shafts
be adapted to conduct the bars carrying the needles or heckle-teeth through a
ιine for preparing, drawing, or roving textile fibres.

December, 1835, Messrs. Hope and Dewhurst obtained a patent for improvements
e manufacture of flax, which deserve notice.   These are of both a chemical and
anical nature.   The first consists in steeping the flax in dilute sulphuric acid, of a
in strength, and for a certain time, proportioned to the quality of the fibres, the
er requiring the stronger application.   By this means the gummy matter and the
shell will be loosened and easily detached.   It is then to be passed between squeez-
ollers, afterwards well washed, boiled in a solution of soap and water for a few
ι, and finally passed again through the rollers.   These processes may be repeated
ιe flax acquires the desired glossiness and separation of fibres.   It is next to be
n, and passed once or twice over an ordinary heckle or stiff brush.
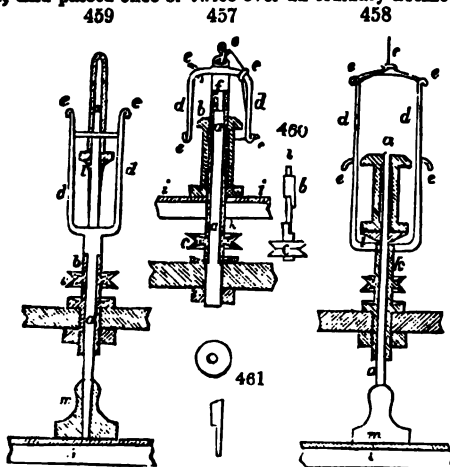
459   457   458

The second part, or the me-
chanical, is represented by the
figures 457, 458, 459, 460, and
461.   *Fig.* 457 is a sectional
elevation in part of the con-
struction of the spindle, bobbin,
and flier, proposed for spin-
ning all kinds of flax or hemp.
Fig. 458 answers for spinning
coarser yarns; *fig.* 459 shows
how yarns are to be spun for
weft, and wound upon what is
called a "pin cop bobbin."

a a a is the stationary or
fixed spindle of the ordinary
throstle frame, which is sur-
rounded by the tube *b b*, and
connected to the wharve or pul-
ley *c*, by which the flier *d* is
driven.   The flier is furnished
with guides or conductors, *e e*,
which lead the yarn immedi-

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r to the bobbin; this flier is also provided with a small central shaft which supports it,
runs in the small cup or recess at the top of the stationary spindle *a*, and is fixed with
flier to the tube *b b*, which is altogether carried round or driven by the wharve *c*.

will be seen by *fig.* 460 that the wharve *c* and tube *b* are connected at bottom
ι half-lap coupling joint or clutch; this is for the purpose of allowing the tube *b* to be
ιen up the spindle, and more readily removing the bobbin when it is full of yarn,
ιout stopping the frame, or removing the band from the wharve *c*, the tube of which
ι in the step or cup *h*, fixed upon the bolster rail near the bottom of the throstle frame.
traversing of the bobbin or the copping motion is effected exactly in the same man-
as in ordinary throstles, that is, by the lifting and lowering of the copping rail *i*,
ιh in this instance supports the bobbin.   In *fig.* 458 the flier is constructed of twice
length of the bobbin, to allow this to rise and fall freely within it, and is connected
ιp by a slight cross piece, for the purpose of preventing the arms of the flier from
ιnding by the centrifugal force, when turning with great velocity.   The flier for spin-
ι coarse numbers requires to have an inner tube, *k*, to support the spindle.   The
ιins are supported upon a washer, *l l*.   The spindle is allowed to revolve in a slight
ιe by the friction of the drag-weight *m m*.   This weight has a hole formed in it
ι a flat side, as shown in *fig.* 461.

ιax has been for a long period spun wet in the mills; a method no doubt copied
ι the practice of housewives moistening their yarn with their saliva at the domestic
ιel.   Within a few years the important improvement has been introduced of sub-
ιting hot for cold water, in the troughs through which the fibres in the act of
ιing pass.   By this means a much finer, smoother, and more uniform thread can
ιpun than in the old way.   The flax formerly spun to twelve pounds a bundle is,
ι hot water, spun to six.   The inconvenience of the spray thrown from the yarn on
ιfliers remains, aggravated by increased heat and dampness of the room where this
ιprocess goes on.   Being a new expedient, it receives daily changes and ameliora-
ι.   When first employed, the troughs of hot water were quite open; they are now

usually covered in, so as almost entirely to obviate the objections to which they were previously liable. With the covers has been also introduced a new method of piecening or joining on any end, which may have been run down, namely, by splicing it to the adjoining roving, whereby it is carried through the water without imposing a necessity on the spinner to put her hand into the water at all. In some places she uses a wire, for the purpose of drawing through the end of the roving to mend a broken yarn.

This may be considered the inherent evil of flax-spinning,—the spray thrown off by the wet yarn, as it whirls about with the flier of the spindles. A working dress, indeed, is generally worn by the spinners; but, unless it be made of stuff impermeable to water, like Mackintosh's cloth, it will soon become uncomfortable, and cause injury to health by keeping the body continually in a hot bath. In some mills, water-proof cloth and leather aprons have actually been introduced, which are the only practicable remedy; for the free space which must be left round the spindles for the spinner to see them play, is incompatible with any kind of fixed guard or *parapluie.*

There was, before the late Factory Bill passed, a class of very young children employed in the flax mills, under the name of little doffers, forming generally a troop of from four to ten in each spinning-room, who, the moment they perceived the bobbins of any frame or side of a frame exhausted of roving, ran together, and furnished it with full ones as quickly as possible. They were not numerous in all, but they had an occupation requiring a great activity and attention. It was practised also in the fine spinning-rooms, which are perfectly free from dust; and, as it involved a kneeling and stooping position, seemed peculiarly appropriate to children, and is still done by them at a somewhat more advanced age.

The adjoining *fig.* 462 will serve to explain the mechanism by which the fine

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spinning of flax is performed. The front pair of drawing rollers represented at F was at one time moistened by letting water trickle upon it, from a vessel B, furnished with a stopcock placed a little above, or by immersing one half of the under-roller in the water-trough as at A. The roller pair c, which receives the fine rovings from bobbins placed on skewers or upright pins in the creel behind, is so mounted as to be fixed at any desired distance from the front rollers F. This distance should be always a little more than the average length of the filaments of the line; for if it were equal to it, they would be seized at both ends by the two pairs of rollers, which move with different velocities, and would be torn asunder, instead of being drawn out alongside of each other. The front rollers, indeed, move in many such machines four times faster than the back pair. The rest of this flax-spinning apparatus resembles in every respect the throstle frame of the cotton-spinner. The

thread, as it escapes from the front rollers, gets twisted by the spindle and flier, and wound up in constant progression on the bobbin, the motion of the latter being retarded either by a washer of leather beneath its lower end, or sometimes, as shown in the figure, by a weighted lever H, suspended from a cord, which embraces the pulley-groove turned on the lower end of the bobbin. This friction of this cord on the pulley, which may be varied by changing the length of leverage at which the weight acts, gives the bobbin the requisite retardation for winding up the thread.

The bobbin G, at the same time that it has this retarded movement of revolution on its axis, has another motion up and down on the spindle I, to present itself at different points to the thread, and to cause the equal distribution of this over the surface of the bobbin-barrel. This latter motion is given by a double eccentric I, which, by turning slowly on its axis, makes the balance-lever M oscillate, and thereby raises or depresses the bobbin-rail with its row of spindles. N is a section of the long tin drum, which

ds the whole breadth of the frame, and communicates its rotatory motion, derived
the steam-pulley, to the spindles, by the intervention of the endless cotton cords o,
10 to the fluted rollers c, F, and to the axis of the heart-shaped or eccentric wheel L,
ing in an endless screw.

e ratio of the velocity of the rollers of supply c, with the front or delivering rollers
d with the spindles, is proportional to the fineness of the yarn. For low numbers,
raught is usually fourfold. The speed of the spindles also varies with the quality
e yarn, according as it is intended for warp or weft; the former requiring more
than the latter; but never so much as to cause it to snarl into a knot, when left free
rn on itself.

e of the most important improvements hitherto made in the spinning of flax is that
hich James Kay, of Preston, obtained a patent in July, 1825. Its peculiar feature
: maceration in warm water of the slivers or rovings, previously to spinning them,
nducting them into tin cans, with open bottoms, fitted into circular boxes having
like a cullender, and immersed into a trough of warm water. The slivers as they
from the rollers are let fall through the cans into these boxes, when they are to be
tedly pressed and beaten down by a plunger, or the action of rollers, as may be most
:nient. The material must be thoroughly freed from air, and macerated. After
r six hours it is to be removed from the water, and placed in its compressed state
: back part of a drawing and spinning machine. The cake being now turned over,
nd of the roving first deposited in the can is drawn out with care, then raised up,
assed over a tension roller to the drawing apparatus. The first pair of rollers for
rawing process merely retains the filaments; while at a distance of two inches and
: the drawing rollers are placed. Both are fluted, for the purpose of taking firm
of the material; and the drawing pair is made to move eight times quicker than the
ing. As the flax fibres have in this state little or no elasticity, and as they adhere
y in their macerated condition, the drawing rollers must be placed thus close to
:taining rollers, and being made to move at a proper speed, produce an extremely
nated thread.

e adjoining table represents, in three compartments, the most important rooms in a
nill, viz. :—

The tow preparing room.
The line preparing room for the long flax.
. One room of spinning machines as a pattern for the rest.

463   TOW PREPARING ROOM.
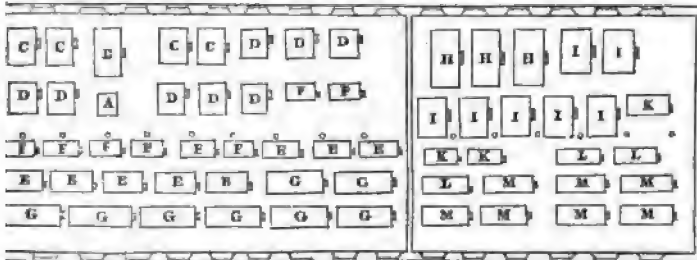
lap machine; B, 4-feet breaker card; c, 3 feet 6 inches ditto; D, 3-feet finisher
3 workers; E, cut tow, second drawing, 5 heads; F, cut tow, first drawing, 4 heads;
t tow, reg. roving, 32 spindles; H, 4-feet breaker card; I, 4-feet finisher ditto; x,
tow, first drawing, 3 heads; L, long tow, second drawing, 4 heads; M, long tow
g 4 spindles.

           LINE PREPARING ROOM.   464
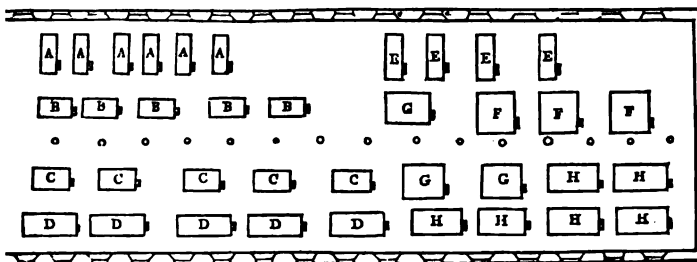
A, cut line, first drawing; B, cut line, second **drawing**, 4 **heads**; C, **cut** line, **third** drawing, 5 heads ; D, cut line, reg. roving 32 spindles each ; E, **long line, first drawing**; F, long line, second drawing, 3 heads each ; G, **long line, third drawing, 4 heads each**; H, long line, roving 16 spindles.

SPINNING ROOM.   465
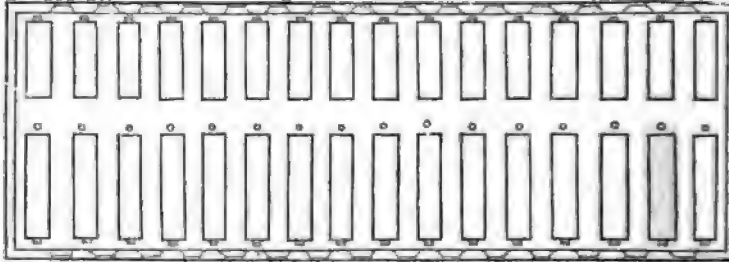
I. The line preparing room comprehends : —
1. Heckling machines with heckles.
2. Line spreaders, or first drawing slivers.
3. Frames for the second drawing, of 3 heads each.
4. Frames for the third drawing, of 4 heads each.
5. Roving frames of 16 spindles each.
6. Spare fallers for first drawing with gills.
7. Ditto ditto for second and third drawing with ditto.
8. Ditto ditto for roving.

II. The cut flax line preparing room : —
1. Sets of heckling frames (eccentric.)
2. Cutting or breaking machine.
3. Line spreaders or drawing ditto.
4. Frames for second drawing, 4 heads each.
5. Ditto   third ditto,   5 ditto.
6. Ditto, regulator roving, 32 spindles each.
7. Spare fallers with gills for first drawing.
8. Ditto, ditto   for second and third ditto.
9. Ditto, ditto, with gills for roving.

III. Long or uncut flax tow preparation : —
1. Lap machine.
2. Breaker cards, 4 feet diameter.
3. Finisher ditto, ditto.
4. Frames for first drawing, 3 heads each.
5. Ditto for second drawing, 3 heads each.
6. Ditto for roving, 16 spindles each.
7. Spare fallers, with gills for first and second drawing.
8. Ditto, ditto,   ditto,   for roving.

IV. Cut flax tow preparation : —
1. Lap machine.
2. First breaker cards, 4 feet diameter.
3. Second ditto, ditto, 3 feet 6 inches ditto.
4. Finisher cards with 8 workers.
5. First drawing frames, of 4 heads each.
6. Second ditto, ditto,   of 5 ditto.
7. Frames for regulator roving, 32 spindles each frame.
8. Spare fallers with gills for first and second drawing.
9. Ditto, ditto,   for roving.

V. Spinning rooms for both lines and tows :—spindles in frames in a number proportional to the number of the above preparation machines; and consequently to the quantity and quality of the flax yarn intended to be spun.

VI. Utensils and tools ; such as cards clothing with needle pointed filleting.

Observations upon the above statement of the series of machinery requisite in a modern flax mill of the most improved construction : —

The long or uncut flax to be spun into yarns averaging 30 leas per lb.

Each heckling machine will produce about 4½ cwts. per day, which would be distributed into 200 lbs. of line, and 266⅔ of tow.

The total with 3 machines would be therefore 600 lbs. of line, and 800 lbs. of tow.

The preceding statement contains three systems of line preparing, each **system being composed** of —

1 line spreader, or first drawing;

1st frame of 3 heads; 2d ditto, 2 slivers each;

1 ditto of 4 ditto; 3d ditto, ditto ditto;

2 ditto rovings, of 32 spindles, which are capable of supplying about 640 spinning do.;

1 line spreader being allowed for contingencies.

The above statement contains 3 systems of tow (uncut) preparation, each system being composed of—

1 breaker card;

2 finisher ditto;

1 frame of first drawing, 3 heads of 4 slivers each;

1 ditto second ditto, 4 ditto, 4 ditto ditto;

2¼ ditto rovings, or 37 spindles, which are capable of supplying about 660 spinning do.;

1 lap machine being sufficient for 2 or 3 systems;

1 extra finisher is deemed desirable.

The statement contains 2 systems of heckling machines for cut flax, a system consisting of either 8 or ten machines; for the coarser work, 8 machines in succession, finer and finer, are sufficient; but for the finest, 10 or 12 are required. Each system will produce between 2 and 300 lbs. per diem of raw flax, heckled, divided on the average into 170 lbs. line, 280 lbs. tow, which will about equal the supply of the 5th system contained in the statement, each consisting of—

1 line spreader or 1st drawing;

1 frame 2d drawing; 4 heads, 4 slivers each;

1 ditto 3d ditto, 5 ditto, 4 ditto ditto;

1 ditto roving, 32 spindles;

and are capable of supplying about 480 ditto, of spinning.

The statement contains 2 systems of tow (cut flax) preparings, each system being composed of—

2 second breaker cards :

4 finishers ditto;

4 frames 1st drawing, 4 heads, each 4 slivers;

4 ditto 2d ditto, 5 ditto ditto 4 ditto;

4 regulator rovings, 128 spindles;

and are capable to supply about 1800 spinning ditto.

1 first-breaker card and lap frame are sufficient to 2 or 3 systems.

Summary view :—

Long or uncut line 3 systems of 640 spindles = 1920					
Ditto	—	tow 3 ditto	660 ditto	1980	3900
Cut	—	line 5 ditto	480 ditto	2400	
Ditto	—	tow 2 ditto	1800 ditto	3600	6000

Total of spinning spindles, 9900

3900 spindles, at an average of 30 leas yarn per lb., would turn off 9 leas per spindle per diem, with waste circa 1400 lbs.

6000 spindles, at an average of 100 leas yarn per lb., would turn off 6 leas per spindle per diem, with waste circa 450 lbs.

Yarns produced :

		£.	s.	d.
Of average 30 leas per lb. per week circa 1050 boles at 9s.		472	10	0
Of ditto 100 ditto — — 1060 —		486	0	0
Total weekly produce, 2130		958	10	0

	£.	s.	d.			
Weekly charges, wages, &c. -	- 150	0	0			
Flax - - -	- 400	0	0			
Weekly expenses	- 40	0	0			
Interest on 60,000l. }	120	0	0		710	0 0
10 per annum }						

Weekly profit 248 10 0

Measures of flax yarn, and statistics of the linen trade for the United Kingdom.

One lea of flax yarn at Leeds is	= 300 yards.
One spindle Scotch	= 38 leas = 11400 yards.
One rand	= 6 ditto = 1800 ditto.
One dozen is 12 rands	= 72 ditto = 21600 ditto.

When yarn is estimated in Nos. it implies the number of leas in one pound weight; as in cotton, it means the number of hanks of 840 yards each in one pound.

33

Imports of flax and tow, or codilla of hemp and flax, at a duty of 1d. per cwt., in

	1834.	1835.	1837.	1838.
	lbs.	lbs.	lbs.	lbs.
	811,722	740,814	1,529,116	1,002,256
Retained for consumption:				
	794,272	728,142	1,582,059	1,002,408
Linen yarn exported - - -	2,611,215			
Linen manufactures exported, including				
flax yarn, declared value - -	£3,208,139	£3,645,097	£2,613,298	

FLINT. (*Pierre à fusil*, Fr.; *Feuerstein*, Germ.) The fracture of this fossil is perfectly conchoidal, sometimes glossy, and sometimes dull, on the surface. It is very hard, but breaks easily, and affords very sharp-edged splintery fragments; whence it is a stone which strikes most copious sparks with steel. It is feebly translucid, has so fine and homogeneous a texture as to bear polishing, but possesses little lustre. Its colors are very various, but never vivid. The blackish-brown flint is that usually found in the white chalk. It is nearly black and opaque, loses its color in the fire, and becomes grayish-white and perfectly opaque. Flints occur almost always in nodules or tubercular concretions of various and very irregular forms. These nodules distributed in strata among the chalk, alongside of one another and almost in contact, form extensive beds; interrupted, indeed, by a multitude of void spaces, so as to present, if freed from the earthy matter in which they are imbedded, a species of network with meshes, very irregular both in form and dimension.

The nodules of silex, especially those found in the chalk, are not always homogeneous and solid. Sometimes there is remarked an organic form towards their centre, as a madrepore or a shell, which seems to have served as their nucleus; occasionally the centre is hollow, and its sides are studded over with crystals of quartz, carbonate of iron, pyrites, concretionary silex or calcedony, filled with pulverulent silica, nearly pure, or silex mixed with sulphur; a very singular circumstance.

Flints are observed to be generally humid when broken immediately after being dug out of the ground; a property which disappears after a short exposure to the air. When dried they become more brittle and more splintery, and sometimes their surfaces get covered at old fractures with a thin film or crust of opaque silex.

Flints calcined and ground to a powder enter into the composition of all sorts of fine pottery ware.

The next important application of this silicious substance is in the formation of gun-flints, for which purpose it must be cut in a peculiar manner. The following characters distinguish good flint nodules from such as are less fit for being manufactured. The best are somewhat convex, approaching to globular; those which are very irregular, knobbed, branched, and tuberose, are generally full of imperfections. Good nodules seldom weigh more than 20 pounds; when less than 2, they are not worth the working. They should have a greasy lustre, and be particularly smooth and fine grained. The color may vary from honey-yellow to blackish-brown, but it should be uniform throughout the lump, and the translucency should be so great as to render letters legible through a slice about one fiftieth of an inch thick, laid down upon the paper. The fracture should be perfectly smooth, uniform, and slightly conchoidal; the last property being essential to the cutting out of perfect gun flints.

Four tools are employed by the gun-flint makers.

First, a hammer or mace of iron with a square head, from 1 to 2 pounds weight, with a handle 7 or 8 inches long. This tool is not made of steel, because so hard a metal would render the strokes too harsh, or dry, as the workmen say, and would shatter the nodules irregularly, instead of cutting them with a clean conchoidal fracture.

Second, a hammer with 2 points, made of good steel well hardened, and weighing from 10 to 16 ounces, with a handle 7 inches long passing through it in such a way that the points of the hammer are nearer the hand of the workman than the centre of gravity of the mass.

Third, the disc hammer or roller, a small solid wheel, or flat segment of a cylinder, parallel to its base, only two inches and a third in diameter, and not more than 12 ounces in weight. It is formed of steel not hardened, and is fixed upon a handle 6 inches long, which passes through a square hole in its centre.

Fourth, a chisel tapering and bevelled at both extremities, 7 or 8 inches long, and 2 inches broad, made of steel not hardened; this is set on a block of wood, which serves also for a bench to the workmen. To these 4 tools a file must be added, for the purpose of restoring the edge of the chisel from time to time.

After selecting a good mass of flint, the workman executes the following four operations on it.

1. *He breaks the block.* Being seated upon the ground, he places the nodule of flint on

his left thigh, and applies slight strokes with the square hammer to divide it into smaller pieces of about a pound and a half each, with broad surfaces and almost even fractures. The blows should be moderate, lest the lump crack and split in the wrong direction.

2. *He cleaves or chips the flint.* The principal point is to split the flint well, or to chip off scales of the length, thickness, and shape adapted for the subsequent formation of gun flints. Here the greatest dexterity and steadiness of manipulation are necessary; but the fracture of the flint is not restricted to any particular direction, for it may be chipped in all parts with equal facility.

The workman holds the lump of flint in his left hand, and strikes with the pointed hammer upon the edges of the great planes produced by the first breaking, whereby the white coating of the flint is removed in small scales, and the interior body of the flint is laid bare; after which he continues to detach similar scaly portions from the clean mass.

These scaly portions are nearly an inch and a half broad, two inches and a half long, and about one sixth of an inch thick in the middle. They are slightly convex below, and consequently leave in the part of the lump from which they were separated a space slightly concave, longitudinally bordered by two somewhat projecting straight lines or ridges. The ridges produced by the separation of the first scales must naturally constitute nearly the middle of the subsequent pieces; and such scales alone as have their ridges thus placed in the middle are fit to be made into gun-flints. In this manner the workman continues to split or chip the mass of flint in various directions, until the defects usually found in the interior render it impossible to make the requisite fractures, or until the piece is too much reduced to sustain the smart blows by which the flint is divided.

3. *He fashions the gun-flints.* Five different parts may be distinguished in a gun-flint. 1. The sloping facet or bevel part, which is impelled against the hammer of the lock. Its thickness should be from two to three twelfths of an inch; for if it were thicker it would be too liable to break; and if more obtuse, the scintillations would be less vivid. 2. The sides, or lateral edges, which are always somewhat irregular. 3. The back or thick part opposite the tapering edge. 4. The under surface, which is smooth and rather concave. And 5. The upper face, which has a small square plane between the tapering edge and the back, for entering into the upper claw of the cock.

In order to fashion the flint, those scales are selected which have at least one of the above mentioned longitudinal ridges; the workman fixes on one of the two tapering borders to form the striking edge, after which the two sides of the stone that are to form the lateral edges, as well as the part that is to form the back, are successively placed on the edge of the chisel in such a manner that the convex surface of the flint, which rests on the forefinger of the left hand, is turned towards that tool. Then with the disc hammer he applies some slight strokes to the flint just opposite the edge of the chisel underneath, and thereby breaks it exactly along the edge of the chisel.

4. The finishing operation is the *trimming*, or the process of giving the flint a smooth and equal edge; this is done by turning up the stone and placing the edge of its tapering end upon the chisel, in which position it is completed by 5 or 6 slight strokes of the disc hammer. The whole operation of making a gun-flint, which I have used so many words to describe, is performed in less than one minute. A good workman is able to manufacture 1000 good chips or scales in a day (if the flint-balls be of good quality), or 500 gun-flints. Hence, in the space of 3 days, he can easily cleave and finish 1000 gun-flints without any assistance.

A great quantity of refuse matter is left, for scarcely more than half the scales are good, and nearly half the mass in the best flints is incapable of being chipped out; so that it seldom happens that the largest nodules furnish more than 50 gun-flints.

Flints form excellent building materials; because they give a firm hold to the mortar by their irregularly rough surfaces, and resist, by their nature, every vicissitude of weather. The counties of Kent, Essex, Suffolk, and Norfolk, contain many substantial specimens of flint-masonry.

FLOSS of the puddling furnace, is the fluid glass floating upon the iron produced by the vitrification of the oxydes and earths which are present.

FLOSS-SILK (*Filoselle, Bourre de soie,* or *fleuret,* Fr.) is the name given to the portions of ravelled silk broken off in the filature of the cocoons, which is carded like cotton or wool, and spun into a soft coarse yarn or thread, for making bands, shawls, socks, and other common silk fabrics. The floss or fleuret, as first obtained, must be steeped in water, and then subjected to pressure, in order to extract the gummy matter, which renders it too harsh and short for the spinning-wheel. After being dried it is made still more pliant by working a little oil into it with the hands. It is now ready to be submitted to the carding engine. See COTTON MANUFACTURE. It is spun upon the flax wheel.

The female peasants of Lombardy generally wear clothes of homespun floss-silk. Of late years, by improved processes, pretty fine fabrics of this material have been pro-

duced both in England and France. M. Ajac, of Lyons, presented at one of the French national exhibitions of the objects of industry, a great variety of scarfs and square shawls, of *bourrs de soie*, closely resembling those of *cachemire*.

FLOUR; the finely ground meal of wheat, and of any other corns or cerealia. See BREAD.

FLOUR OF WHEAT, *Adulterations of, to detect.*

The first method is by specific gravity. If potato flour be added, which is frequently done in France, since a vessel which contains one pound of wheat flour will contain one pound and a half of the fecula, the proportion of this adulteration may be easily estimated. If gypsum or ground bones be mixed with the flour, they will not only increase its density still more, but they will remain after burning away the meal.

The second method is by ascertaining the quantity of gluten which the suspected sample will afford, by the process prescribed under the article BREAD. The two following chemical criteria may also be employed.

1st. Nitric acid has the property of coloring wheat flour of a fine orange-yellow, whereas it affects the color neither of fecula nor starch.

2d. Pure muriatic acid colors good wheat flour of a deep violet, but dissolves fecula or starch, and forms with it a light, colorless, viscous fluid, decomposable by alkalis. It may also be observed, that as fecula absorbs less water than flour, this affords a ready means of detection.

The adulteration with bean or pea flour may be detected by pouring boiling water upon it, which developes the peculiar smell of these two substances.

FLOWERS (*Fleurs*, Fr.; *Blumen*, Germ.) of benzoin, of sulphur, of zinc, &c., is the appellation given by the older chemists to such substances as were obtained in a pulverulent or rather minutely crystalline form by the process of sublimation.

FLOWERS, ARTIFICIAL, MANUFACTURE OF. The art of representing by flowers, leaves, plants, &c., vegetable nature in her ornamental productions, constitutes the business of the artificial florist. The Italians appear to have been the first people in Europe who excelled in the art of making artificial flowers; but of late years the French have been most ingenious in this branch of industry.

Ribands folded in different forms and of different colors were originally employed for imitating flowers, by being attached to wire stems. This imitation soon gave way to that by feathers, which are more delicate in texture, and more capable of assuming a variety of flower-like figures. But a great difficulty was encountered in dyeing them with due vivacity. The savages of South America manufacture perfect feather flowers, derived from the brilliant plumage of their birds, which closely resemble the products of vegetation. The blossoms and leaves are admirable, while the colors never fade.

The Italians employ frequently the cocoons of the silkworm for this purpose; these take a brilliant dye, preserve their color, and possess a transparent velvety appearance, suitable for petals. Of late years, the French have adopted the finest cambric for making petals, and the taffeta of Florence for the leaves. M. de Bernardiere employs whalebone in very thin leaves for artificial flowers; and by bleaching and dyeing them of various hues, he has succeeded in making his imitations of nature to be very remarkable.

The coloring matters used in flower dyeing are the following : —

For red; carmine dissolved in a solution of salt of tartar.

For blue; indigo dissolved in sulphuric acid, diluted and neutralized in part by Spanish whitening.

For bright yellow; a solution of turmeric in spirit of wine. Cream of tartar brightens all these colors.

For violet; archil, and a blue bath.

For lilach; archil.

Some petals are made of velvet, and are colored merely by the application of the finger dipped in the dye.

FLUATES, more properly *fluorides* (Eng. and Fr.; *Flusssäure*, Germ.); compounds of fluorine and the metals; as fluor spar, for example, which consists of fluorine and calcium.

FLUOR SPAR. (*Chaux fluatée* Fr.; *Spath fluor*, Germ.) This mineral often exhibits a variety of vivid colors. It crystallizes in the cubic system: with regular octahedral and tetrahedral cleavages; spec. grav. 3·1 to 3·2; scratches calc spar, but is scratched by a steel point; usually phosphorescent with heat; fusible at the blowpipe into an opaque bead; acted on by the acids, with disengagement of a vapor which corrodes glass; its solution affords precipitates with the oxalates, but not with ammonia. Its constituents are, fluorine, 48·13; calcium, 51·87 in 100.

Fluor spar occurs subordinate to metallic veins; as to those of lead, in Derbyshire; of tin, in Saxony and Bohemia; but it is found also in masses or veins, either in crystalline rocks, associated with quartz, heavy spar, &c., as in Auvergne, Forez, Vosges, Norberg in Sweden; Norway; Petersburg; near Hall; Gourock, in Scotland, &c.; or

lary limestones, slates, and sandstones, in Derbyshire, Cumberland, Corn
v Jersey.   It exists also in the amygdaloids of Scotland, and in the vol-
s of Monte Somma at Vesuvius.   The variously colored specimens, called
ar, are worked upon the turning-lathe into vases and other ornamental

g. and Fr.; *Fluss*, Germ.) signifies any substance capable of promoting the
hs or metallic ores by heat.   White flux is the residuum of the deflagration
·ucible, of a mixture of two parts of nitre, and one of cream of tartar.   It
·ly a carbonate of potash.   Black flux is obtained when equal parts of nitre
deflagrated.   It owes its color to the carbonaceous matter of the tartaric
·mains unconsumed; the quantity of nitre being too small for that purpose.
of the charcoal renders this preparation a convenient flux for reducing cal-
zed ores to the metallic state.   Limestone, fluor-spar, borax, and several
illic oxydes are employed as fluxes in metallurgy.
DER; the black colored powder obtained by the spontaneous oxydizement
senic in the air.
s the name of a weight by which lead and some other metals are sold in
It varies in its amount in different parts of the kingdom; being in Northum-
ited at 21 cwts., and in other counties 22, 23, or even more cwts.
s the name given by the French to a particular style of calico-printing
·rainbow, in which the colors are graduated or melted (*fondus*) into one
the prismatic spectrum.   See PAPER HANGINGS, for a description of the

:ng. and Fr.; *Feuer*, Germ.) is the name either of the furnace, where
is hammered and fashioned with the aid of heat, or the great workshop
made malleable.   The former is called a smith's forge, the latter a shingling
N.   466
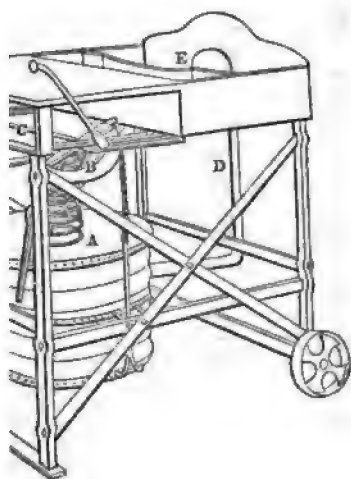
Fig. 466 represents a portable
truck forge of a very commodious
construction.   A is the cylindric
leather bellows, pressed down by a
helical spring, and worked by
means of the handle at B, which
moves the horizontal shaft c, with
its two attached semicircular levers
and chains.   D is the pipe which
conducts the blast to the nozzle at
E.   The hearth may be covered
with a thin fire-tile or with cin-
ders.   F is a vice fixed to the strong
rectangular frame.   This appara-
tus answers all the ordinary pur-
poses of a smith's forge; and is
peculiarly adapted to ships, and to
the execution of engineering jobs
upon railways, or in the country.
The height is 2 feet 6 inches; the
length is 2 feet 9 inches; the
width 2 feet.   Weight about 2
cwts.

ES are compounds of formic acid, with the salifiable bases.   Many of them
· of crystallization.
\CID (*Acide Formique*, Fr; *Ameisansaure*, Germ.) exists in the bodies of
ociated with the malic or acid of apples.   The artificial formation of this
·n is one of the most remarkable triumphs of modern chemistry.   If 10
ic acid, 14 of black oxyde of manganese, 15 of concentrated sulphuric acid,
·30 of water be mixed and distilled in a retort, formic acid will be the liquid
· carbonic acid will be disengaged.   It may also be generated from other
his acid is transparent and colorless, of a pungent sour smell, a strongly
·pecific gravity 1·1168 at 60° F., and may be re-distilled without suffering
It contains in its most concentrated form 19¾ per cent. of water.   The
· exists in the *formiates*, is composed of 32·54 carbon, 2·68 hydrogen, and
or of two volumes carbonic oxyde gas, and one volume of vapor of water.
oxydes of mercury and silver to the metallic state.   It has not hitherto
· any use in the arts.
:, CHEMICAL, are symbols representing the different substances, simple

Name.			Formula.	Oxygen =100	Hydrogen =1
Oxygen	.	.	O	100·000	16·026
Hydrogen	.	.	H	6·2398	1·000
			2H	12·4796	2·000
Nitrogen	.	.	N	88·518	14·186
			2N	177·086	28·372
Phosphorus	.	.	P	196·155	31·436
			2P	392·310	68·872
Chlorine	.	.	Cl	221·325	35·470
			2Cl	442·650	70·940
Iodine .	.	.	I	768·781	123·206
			2I	1537·562	246·412
Carbon	.	.	C	76·437	12·250
			2C	152·875	24·500
Boron .	.	.	B	135·983	21·793
			2B	271·966	43·586
Silicon .	.	.	Si	277·478	44·469
Selenium	.	.	Se	494·582	79·263
Arsenic	.	.	As	470·042	75·329
			2As	940·084	150·659
Chromium	.	.	Cr	351·819	56·383
			2Cr	703·638	112·766
Molybdenum	.	.	Mo	598·525	96·920
Tungstenium	.	.	Tu or W	1183·200	189·621
Antimony	.	.	Sb	806·452	129·243
			2Sb	1612·904	258·486
Tellurium	.	.	Te	806·452	129·243
Tantalum	.	.	Ta	1153·715	184·896
			2Ta	2307·430	369·792
Titanium	.	.	Ti	389·092	62·356
Gold (aurum)	.	.	Au	1243·013	199·207
			2Au	2486·026	398·415
Platina	.	.	Pt	1215·220	194·753
Rhodium	.	.	R	750·680	120·305
			2R	1501·360	240·610
Palladium	.	.	Pd	714·618	114·526
Silver (argentum)		.	Ag	1351·607	216·611
Mercury (hydrargyrus)		.	Hg	1265·822	202·863
			2Hg	2531·645	405·725
Copper (cuprum)	.	.	Cu	395·695	63·415
			2Cu	791·390	126·829
Uranium	.	.	U	2711·360	434·527
			2U	5422·720	869·154
Bismuth	.	.	Bi	1330·376	213·208
			2Bi	2660·752	426·416
Tin (stannum)		.	Sn	735·294	117·839
Lead (plumbum)		.	Pb	1294·498	207·458
			2Pb	2588·996	414·917
Cadmium	.	.	Cd	696·767	111·665
Zinc .	.	.	Zn	403·226	64·621
Nickel	.	.	Ni	369·675	59·245
Cobalt	.	.	Co	368·991	59·135
			2Co	737·982	118·270
Iron (ferrum)	.	.	Fe	339·213	54·363
			2Fe	678·426	108·725
Manganese	.	.	Mn	355·787	57·019
			2Mn	711·575	114·038
Cerium	.	.	Ce	574·718	92·105
			2Ce	1149·436	184·210
Zirconium	.	.	Zr	420·238	67·348
			2Zr	840·476	134·696
Yttrium	.	.	Y	401·840	64·395
Beryllium (glucinum)		.	Be	331·479	53·123
			2Be	662·958	106·247

Name.	Formula.	Oxygen= 100.	Hydrogen= 1.
Aluminum . . .	Al	171·167	27·431
	2Al	342·234	54·863
Magnesium . . .	Mg	158·353	25·378
Calcium . . .	Ca	256·019	41·030
Strontium . . .	Sr	547·285	87·709
Barytum . . .	Ba	856·88	137·325
Lithium . . .	L	127·757	20·474
Natrium (sodium) . .	Na	290·897	46·620
	2Na	581·794	93·239
Kalium (potassium) .	K	489·916	78·515
Ammonia . . .	2N 2H3	214·474	34·372
Cyanogen . . .	2NC	329·911	52·872
Sulphureted hydrogen . .	2HS	213·644	34·239
Hydrochloric acid . .	2H Cl	455·129	72·940
Hydrocyanic acid . .	2HNC	342·390	54·872
Water . . .	2H	112·479	18·026
Protoxyde of nitrogen . .	2Ṅ	277·036	44·398
Deutoxyde of nitrogen .	N̈	188·518	30·212
Nitrous acid . . .	2N̈	477·036	76·449
Nitric acid . . .	2N⃛	677·036	108·503
Hyposulphurous acid . .	Ṡ	301·165	48·265
Sulphurous acid . .	S̈	401·165	64·291
Hyposulphuric acid . .	2S⃛	902·330	144·609
Sulphuric acid . .	S⃛	501·165	80·317
Phosphoric acid . .	2P⃛	892·310	143·003
Chloric acid . . .	2Cl⃛	942·650	151·071
Perchloric acid . .	2Cl	1042·650	167·097
Iodic acid . . .	2I⃛	2037·562	326·543
Carbonic acid . . .	C̈	276·437	44·302
Oxalic acid . . .	2C⃛	452·875	72·578
Boracic acid . . .	2B⃛	871·966	139·743
Silicic acid . . .	S⃛i	577·478	92·548
Selenic acid . . .	S̈e	694·582	111·315
Arsenic acid . . .	2As⃛	1440·084	230·790
Protoxyde of chrome . .	2Cr⃛	1003·638	160·840
Chromic acid . . .	Cr⃛	651·819	104·462
Molybdic acid . .	Mo⃛	898·525	143·999
Tunstic, or wolfram acid .	W⃛	1483·200	237·700
Oxyde of antimony . .	2S⃛b	1912·904	306·565
Antimonious acid . .	S̈b	1006·452	161·296
	2S̈b	2012·904	322·591
Antimonic acid . .	2S⃛b	2112·904	338·617

Name.	Formula.	Oxygen=100.	Hydrogen=1
Oxyde of tellurium	Ṫe	1006·452	161·296
Tantalic acid	2T̈a	2607·430	417·671
Titanic acid	T̈i	589·092	94·469
Protoxyde of gold	2Ȧu	2586·026	414·441
Peroxyde of gold	2Āu	2786·026	446·498
Oxyde of platina	Ṗt	1415·230	226·686
Oxyde of rhodium	2R̈	1801·360	229·669
Oxyde of palladium	Ṗd	814·618	130·582
Oxyde of silver	Ȧg	1451·607	232·657
Protoxyde of mercury	2Ḣg	2631·645	421·782
Peroxyde of mercury	Ḣg	1365·822	219·889
Protoxyde of copper	2Ċu	801·390	142·656
Peroxyde of copper	Ċu	495·695	79·441
Protoxyde of uranium	U̇	2811·360	450·553
Peroxyde of uranium	2U̇	5722·720	917·132
Oxyde of bismuth	2B̈i	2960·752	474·49
Protoxyde of tin	Ṡn	835·294	133·866
Peroxyde of tin	S̈n	935·294	149·692
Oxyde of lead	Ṗb	1394·498	223·484
Minium	2Ṗb	2888·996	462·995
Brown oxyde of lead	P̈b	1494·498	239·511
Oxyde of cadmium	Ċd	796·767	127·691
Oxyde of zinc	Żn	503·226	80·649
Oxyde of nickel	Ṅi	469·675	75·271
Oxyde of cobalt	Ċo	468·991	75·161
Peroxyde of cobalt	2C̈o	1037·982	166·349
Protoxyde of iron	Ḟe	439·213	70·389
Peroxyde of iron	2F̈	978·426	156·604
Protoxyde of manganese	Ṁn	455·787	73·045
Oxyde of manganese	2M̈n	1011·575	162·117
Peroxyde of manganese	M̈n	555·787	89·071
Manganesic acid	2Ṁn	1211·575	194·169
Protoxyde of cerium	Ċe	674·718	108·122
Oxyde of cerium	2C̈e	1449·436	232·259
Zirconia	2Żr	1140·476	182·775
Yttria	Ẏ	501·840	80·425
Glucina, or berryllia	2B̈e	962·958	154·325

Name.	Formula.	Oxygen=100.	Hydrogen=1.
Alumina . . .	$\overset{...}{\text{Al}}$2	642·334	109·942
Magnesia . . .	$\dot{\text{Mg}}$	258·353	41·404
Lime	$\dot{\text{Ca}}$	356·019	57·056
Strontia . . .	$\dot{\text{Sr}}$	647·285	103·735
Baryta . . .	$\dot{\text{Ba}}$	956·880	153·351
Lithia . . .	$\dot{\text{L}}$	227·757	36·501
Natron, or soda . .	$\dot{\text{Na}}$	390·897	62·646
Peroxyde of sodium . .	$\overset{...}{\text{Na}}$2	881·794	141·318
Kali, or potassa . .	$\dot{\text{K}}$	589·916	94·541
Peroxyde of potassium .	$\overset{...}{\text{K}}$	789·916	126·593
Sulphate of potassa . .	$\dot{\text{K}}\overset{..}{\text{S}}$	1091·081	174·859
Protosulphate of iron . .	$\dot{\text{Fe}}\overset{...}{\text{S}}$	940·378	150·706
Persulphate of iron . .	$\overset{..}{\text{Fe}}\overset{...}{\text{S}}$3	2481·906	397·754
Protochloride of iron . .	Fe 2Cl	781·863	125·303
Perchloride of iron . .	2Fe 2Cl³	2006·376	321·545
Protochloride of mercury .	2Hg 2Cl	2974·295	476·666
Perchloride of mercury .	Hg 2Cl	1708·472	273·803
Ferrocyanide of iron . .	Fe 2NC+2K 2NC	2308·778	370·008
Alum	$\dot{\text{K}}\overset{..}{\text{S}}+2\overset{...}{\text{Al}}\overset{..}{\text{S}}3+24\ 2\dot{\text{H}}$	5936·406	951·378
Feldspar . . .	$\dot{\text{K}}\overset{...}{\text{Si}}+2\overset{...}{\text{Al}}\overset{...}{\text{Si}}3$	3542·162	567·673

FOUNDING *of metals, chiefly of Iron.* The operations of an iron foundry consist in melting the pig-iron of the blast furnaces, and giving it an endless variety of forms, casting it in moulds of different kinds, prepared in appropriate manners. Coke is the ly kind of fuel employed to effect the fusion of the cast-iron.

The essential parts of a well-mounted iron foundry are,

1. Magazines for pig-irons of different qualities, which are to be mixed in certain proportions, for producing castings of peculiar qualities; as also for coal, coke, sands, clay, powdered charcoal, and cow-hair for giving tenacity to the loam mouldings.

2. One or more coke ovens.

3. A workshop for preparing the patterns and materials of the moulds. It should contain small edge millstones for grinding and mixing the loam, and another mill for grinding coal and charcoal.

4. A vast area, called properly the foundry, in which the moulds are made and filled with the melted metal. These moulds are in general very heavy, consisting of two parts at least, which must be separated, turned upside down several times, and replaced very quietly upon one another. The casting is generally effected by means of large ladles or pots, in which the melted iron is transported from the cupola, where it is fused. Hence, the foundry ought to be provided with cranes, having jibs moveable in every direction.

5. A stove in which such moulds may be readily introduced as require to be entirely deprived of humidity, and where a strong heat may be uniformly maintained.

6. Both blast and air furnaces, capable of melting speedily the quantity of cast-iron to be employed each day.

7. A blowing machine to urge the fusion in the furnaces.

Fig. 467 represents the general plan of a well-mounted foundry.

a is a cupola furnace, of which the section and view will be afterwards given; it is capable of containing 5 tons of cast-iron.

d is a similar furnace, but of smaller dimensions, for bringing down 1¾ tons.

c'' is a furnace like the first, in reserve for great castings.

b, b, b, b, a vast foundry apartment, whose floor, to a yard in depth, is formed of sand and charcoal powder, which have already been used for castings, and are ready for heaping up into a substratum, or to be scooped out when depth is wanted for the moulds. There are besides several cylindrical pits, from five to seven yards in depth, placed near the furnaces. They are lined with brick work, and are usually left full of moulding sand. They are emptied in order to receive large moulds, care being had that their top is always below the orifice from which the melted metal is tapped.

467
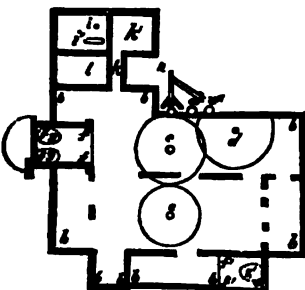
These moulds, and the ladles full of melted metal, are lifted and transported by the arm of one or more men, when their weight is moderate; but if it be considerable, they are moved about by cranes whose vertical shafts are placed at *c, d, e,* in correspondence, so that they may upon occasion transfer the load from one to another. Each crane is composed principally of an upright shaft, embraced at top by a collet, and turning below upon a pivot in a step; next of a horizontal beam, stretched out from nearly the top of the former, with an oblique stay running downwards, like that of a gallows. The horizontal beam supports a moveable carriage, to which the tackle is suspended for raising the weights. This carriage is made to glide backwards or forwards along the beam by means of a simple rack and pinion mechanism, whose long handle descends within reach of the workman's hand.

By these arrangements in the play of the three cranes, masses weighing five tons may be transported and laid down with the greatest precision upon any point whatever in the interior of the three circles traced upon *fig.* 467 with the points *c, d, e,* as centres.

c, d, e, are the steps, upon which the upright shafts of the three cranes rest and turn. Each shaft is 16 feet high.

f, f, is the drying stove, having its floor upon a level with that of the foundry.

f', f', is a supplementary stove for small articles.

g, g, g, are the coking ovens.

h, is the blowing machine or fan.

i, is the steam-engine, for driving the fan, the loam-edge stones,

k, and the charcoal mill.

i'', are the boiler and the furnace of the engine.

k', workshop for preparing the loam and other materials of moulding.

l, is the apartment for the patterns.

The pig-iron, coals, &c. are placed either under sheds or in the open air, round the above buildings; where are also a smith's forge, a carpenter's shop, and an apartment mounted with vices for chipping and rough cleaning the castings by chisels and files.

Such a foundry may be erected upon a square surface of about 80 yards in each side, and will be capable, by casting in the afternoon and evening of each day, partly in large and partly in small pieces, of turning out from 700 to 800 tons per annum, with an establishment of 100 operatives, including some moulding boys.

Of making the moulds.—1. Each mould ought to present the exact form of its object.

2. It should have such solidity that the melted metal may be poured into it, and fill it entirely without altering its shape in any point.

3. The air which occupies the vacant spaces in it, as well as the carbureted gases generated by the heat, must have a ready vent; for if they are but partially confined, they expand by the heat, and may crack, even blow up the moulds, or at any rate become dispersed through the metal, making it vesicular and unsound.

There are three distinct methods of making the moulds :—

1. In green sand; 2. In baked sand; 3. In loam.

To enumerate the different means employed to make every sort of mould exceeds the limits prescribed to this work. I shall merely indicate for each species of moulding, what is common to all the operations; and I shall then describe the fabrication of a few such moulds as appear most proper to give general views of this peculiar art.

Moulding in green sand.—The name green is given to a mixture of the sand as it comes from its native bed, with about one twelfth its bulk of coal reduced to powder, and damped in such a manner as to form a porous compound, capable of preserving the forms of the objects impressed upon it. This sand ought to be slightly argillaceous, with particles not exceeding a pin's head in size. When this mixture has once served for a mould, and been filled with metal, it cannot be employed again except for the coarsest castings, and is generally used for filling up the bottoms of fresh moulds.

For moulding any piece in green sand, an exact pattern of the object must be pre-

pared in wood or metal; the latter being preferable, as not liable to warping, swelling, or shrinkage.

A couple of iron frames form a case or box, which serves as an envelope to the mould. Such boxes constitute an essential and very expensive part of the furniture of a foundry. It is a rectangular frame, without bottom or lid, whose two largest sides are united by a series of cross bars, parallel to each other, and placed from 6 to 8 inches apart.

The two halves of the box carry ears corresponding exactly with one another; of which one set is pierced with holes, but the other has points which enter truly into these holes, and may be made fast in them by cross pins or wedges, so that the pair becomes one solid body. Within this frame there is abundance of room for containing the pattern of the piece to be moulded with its incasing sand, which being rammed into the frame, is retained by friction against the lateral faces and cross bars of the mould.

When a mould is to be formed, a box of suitable dimensions is taken asunder, and each half, No. 1 and No. 2, is laid upon the floor of the foundry. Green sand is thrown with a shovel into No. 1, so as to fill it; when it is gently pressed in with a rammer. The object of this operation is to form a plain surface upon which to lay in the pattern with a slight degree of pressure, varying with its shape. No. 1 being covered with sand, the frame No. 2 is laid upon it, so as to form the box. No. 2 being now filled carefully with the green sand, the box is inverted, so as to place No. 1 uppermost, which is then detached and lifted off in a truly vertical position; carrying with it the body of sand formed at the commencement of the operation. The pattern remains imbedded in the sand of No. 2, which has been exactly moulded upon a great portion of its surface. The moulder condenses the sand in the parts nearest to the pattern, by sprinkling a little water upon it, and trimming the ill-shaped parts with small iron trowels of different kinds. He then dusts a little well-dried finely-sifted sand over all the visible surface of the pattern, and of the sand surrounding it; this is done to prevent adhesion when he replaces the frame No. 1.

He next destroys the preparatory smooth bed or area formed in this frame, covers the pattern with green sand, replaces the frame 1 upon 2, to reproduce the box, and proceeds to fill and ram No. 1, as he had previously done No. 2. The object of this operation is to obtain very exactly a concavity in the frame No. 1, having the shape of the part of the model impressed coarsely upon the surface formed at the beginning, and which was meant merely to support the pattern and the sand sprinkled over it, till it got imbedded in No. 2.

The two frames in their last position, along with their sand, may be compared to a box of which No. 1 is the lid, and whose interior is adjusted exactly upon the enclosed pattern.

If we open this box, and after taking out the pattern, close its two halves again, then pour in melted metal till it fill every void space, and become solid, we shall obviously attain the wished-for end, and produce a piece of cast iron similar to the pattern. But many precautions must still be taken before we can hit this point. We must first lead through the mass of sand in the frame No. 1 one or more channels for the introduction of the melted metal; and though one may suffice for this purpose, another must be made for letting the air escape. The metal is run in by several orifices at once, when the piece has considerable surface, but little thickness, so that it may reach the remotest points sufficiently hot and liquid.

The parts of the mould near the pattern must likewise be pierced with small holes, by means of wires traversing the whole body of the sand, in order to render the mould more porous, and to facilitate the escape of the air and the gases. Then, before lifting off the frame No. 1, we must tap the pattern slightly, otherwise the sand enclosing it would stick to it in several points, and the operation would not succeed. These gentle jolts are given by means of one or more pieces of iron wire which have been screwed vertically into the pattern before finally ramming the sand into the frame No. 1, or which enter merely into holes in the pattern. These pieces are sufficiently long to pass out through the sand when the box is filled; and it is upon their upper ends that the horizontal blows of the hammer are given; their force being regulated by the weight and magnitude of the pattern. These rods are then removed by drawing them straight out; after which the frame No. 1 may be lifted off smoothly from the pattern.

The pattern itself is taken out, by lifting it in all its parts at once, by means of screw pins adjusted at the moment. This manœuvre is executed, for large pieces, almost always by several men, who, while they lift the pattern with one hand, strike it with the other with small repeated blows to detach the sand entirely, in which it is generally more engaged than it was in that of the frame No. 1. But in spite of all these precautions, there are always some degradations in one or other of the two parts of the mould; which are immediately repaired by the workman with damp sand, which he applies and presses gently with his trowel, so as to restore the injured forms.

Hitherto I have supposed all the sand rammed into the box to be of one kind; but

from economy, the green sand is used only to form the portion of the mould next to
pattern, in a stratum of about an inch thick; the rest of the surrounding space is filled
with the sand of the floor which has been used in former castings. The interior layer
round the pattern is called, in this case, new sand.

It may happen that the pattern is too complex to be taken out without damaging the
mould, by two frames alone; then 3 or more are mutually adjusted to form the box.

When the mould, taken asunder into two or more parts, has been properly repaired, its
interior surface must be dusted over with wood charcoal reduced to a very fine powder,
and tied up in a small linen bag, which is shaken by hand. The charcoal is thus sifted
at the moment of application, and sticks to the whole surface, which has been previously
damped a little. It is afterwards polished with a fine trowel. Sometimes, in order to
avoid using too much charcoal, the surfaces are finally dusted over with sand, very finely
pulverized, from a bag like the charcoal. The two frames are now replaced with great
exactness, made fast together by the ears, with wedged bolts laid truly level, or at the
requisite slope, and loaded with considerable weights. When the casting is large, the
charcoal dusting, as well as that of fine sand, is suppressed. Everything is now ready
for the introduction of the fused metal.

Moulding in baked or used sand.—The mechanical part of this process is the same as
of the preceding. But when the castings are large, and especially if they are tall, the
hydrostatic pressure of the melted metal upon the sides of the mould cannot be counter-
acted by the force of cohesion which the sand acquires by ramming. We must in that
case adapt to each of these frames a solid side, pierced with numerous small holes to give
issue to the gases. This does not form one body with the rest of the frame, but is attached
extemporaneously to it by bars and wedged bolts. In general, no ground coal is mixed
with this sand. Whenever the mould is finished, it is transferred to the drying stove,
where it may remain from 12 to 24 hours at most, till it be deprived of all its humidity.
The sand is then said to be baked or annealed. The experienced moulder knows how
to mix the different sands placed at his disposal, so that the mass of the mould as it
comes out of the stove may preserve its form, and be sufficiently porous. Such moulds
allow the gases to pass through them much more readily than those made of green
sand; and in general the castings they turn out are less vesicular, and smoother upon
the surface. Sometimes in a large piece, the three kinds of moulding, that in green
sand, in baked sand, and in loam, are combined to produce the best result.

Moulding in loam.—This kind of work is executed from drawings of the pieces to be
moulded, without being at the expense of making patterns. The mould is formed of a
pasty mixture of clay, water, sand, and cow's-hair, or other cheap filamentous matter,
kneaded together in what is called the loam mill. The proportions of the ingredients are
varied to suit the nature of the casting. When the paste requires to be made very light,
horse dung or chopped straw is added to it.

I shall illustrate the mode of fabricating loam moulds, by a simple case, such as that
of a sugar pan. *Fig.* 468 is the pan. There is laid upon the floor of the foundry an
annular platform of cast-iron, a b, *fig.* 469; and upon its centre c, rests the lower extrem-
ity of a vertical shaft, adjusted so as to turn freely upon itself, while it makes a wooden
pattern, e f, *fig.* 470, describe a surface of revolution identical with the internal surface
reversed of the boiler intended to be made. The outline, e g, of the pattern is fashioned
so as to describe the surface of the edge of the vessel. Upon the part a d b d, *fig.* 469,
of the flat cast-iron ring, there must next be constructed, with bricks laid either flat, or
on their edge, and clay, a kind of dome, h i k, *fig.* 470, from two to four inches thick,

469

468   470
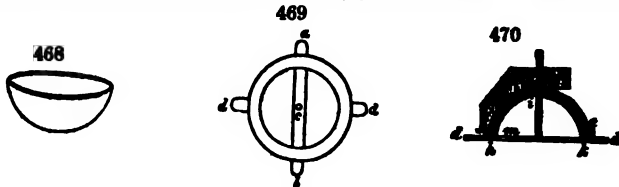
according to the size and weight of the piece to be moulded. The external surface of
the brick dome ought to be everywhere two inches distant, at least, from the surface de-
scribed by the arc e f. Before building up the dome to the point i, coals are to be placed
in its inside upon the floor, which may be afterwards kindled for drying the mould. The
top is then formed, leaving at i, round the upright shaft of revolution, only a very small
outlet. This aperture, as also some others left under the edges of the iron ring, enable
the moulder to light the fire when it becomes necessary, and to graduate it so as to make
it last long enough without needing more fuel, till the mould be quite finished and dry.
The combustion should be always extremely slow.

Over the brick dome a pasty layer of loam is applied, and rounded with the mould

g e f; this surface is then coated with a much smoother loam, by means of the concave edge of the same mould. Upon the latter surface, the inside of the sugar pan is cast; the line e g having traced, in its revolution, a ledge m. The fire is now kindled, and as the surface of the mould becomes dry, it is painted over by a brush, with a mixture of water, charcoal powder, and a little clay, in order to prevent adhesion between the surface already dried and the coats of clay about to be applied to it. The board g e f is now removed, and replaced by another, g' e' f, fig. 471, whose edge e' f describes the outer surface of the pan. Over the surface e, f, a layer of loam is applied, which is turned and polished so as to produce the surface of revolution e' f, as was done for the surface e f; only in the latter case, the line e' g' of the board does not form a new shoulder, but rubs lightly against m.

The layer of loam included between the two surfaces e f, e' f, is an exact representation of the sugar pan. When this layer is well dried by the heat of the interior fire, it must be painted like the former. The upright shaft is now removed, leaving the small vent hole through which it passed to promote the complete combustion of the coal. There must be now laid horizontally upon the ears of the platform d d, fig. 469, another annular platform p q, like the former, but a little larger, and without any cross-bar.

471   472   473
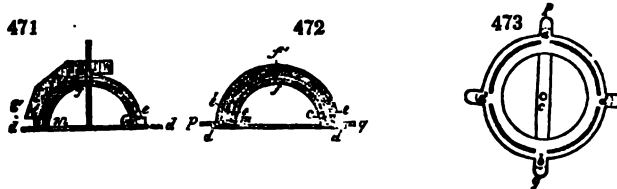
The relative position of these two platforms is shown in fig. 473. Upon the surface e' f, fig. 472, a new layer of loam is laid, two inches thick, of which the surface is smoothed by hand. Then upon the platform p q, fig. 473, a brick vault is constructed, whose inner surface is applied to the layer of loam. This contracts a strong adherence with the bricks which absorb a part of its moisture, while the coat of paint spread over the surface e' f, prevents it from sticking to the preceding layers of loam. The brick dome ought to be built solidly.

The whole mass is now to be thoroughly dried by the continuance of the fire, the draught of which is supported by a small vent left in the upper part of the new dome; and when all is properly dry, the two iron platforms are adjusted to each other by pin points, and p q is lifted off, taking care to keep it in a horizontal position. Upon this platform are removed the last brick dome, and the layer of loam which had been applied next to it; the latter of which represents exactly by its inside the mould of the surface e' f, that is, of the outside of the pan. The crust contained between e f and e' f is broken away, an operation easily done without injury to the surface e f, which represents exactly the inner surface of the pan; or only to the shoulder m, corresponding to the edge of the vessel. The top aperture through which the upright shaft passed must be now closed; only the one is kept open in the portion of the mould lifted off upon p q; because through this opening the melted metal is to be poured in the process of casting. The two platforms being replaced above each other very exactly, by means of the adjusting pin points, the mould is completely formed, and ready for the reception of the metal.

When the object to be moulded presents more complicated forms than the one now chosen for the sake of illustration, it is always by analogous processes that the workman constructs his loam moulds, but his sagacity must hit upon modes of executing many things which at first sight appear to be scarcely possible. Thus, when the forms of the interior and exterior do not permit the mould to be separated in two pieces, it is divided into several, which are nicely fitted with adjusting pins. More than two cast-iron rings or platforms are sometimes necessary. When ovals or angular surfaces must be traced instead of those of revolution, no upright shaft is used, but wooden or cast-iron guides made on purpose, along which the pattern cut-out board is slid according to the drawing of the piece. Iron wires and claws are often interspersed through the brick work to give it cohesion. The core, kernel, or inner mould of a hollow casting is frequently fitted in when the outer shell is moulded. I shall illustrate this matter in the case of a gas-light retort, fig. 474. The core of the retort ought to have the form e e e e, and be very solid, since it cannot be fixed in the outer mould, for the casting, except in the part standing out of the retort towards m m. It must be modelled in loam, upon a piece of cast-iron called a lantern, made expressly for this purpose. The lantern is a cylinder or a truncated hollow cone of cast-iron, about half an inch thick; and differently shaped for every different core. The surface is perforated with holes of about half an inch in diameter. It is mounted by means of iron cross-bars, upon an iron axis,

which traverses it in the direction of its length. Fig. 475 represents a horizontal section through the axis of the core; g h is the axis of the lantern, figured itself at ()
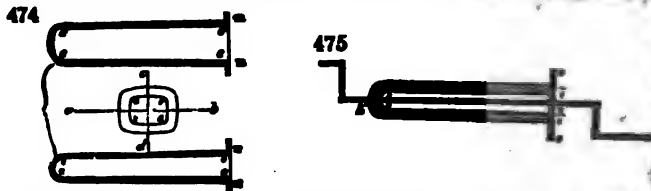
k i; o i i o is a kind of disc or dish, perpendicular to the axis, open at i i, forming one piece with the lantern, whose circumference o o presents a curve similar to the section of the core, made at right angles to its axis. We shall see presently the two uses for which this dish is intended. The axis g h is laid upon two gudgeons, and handles are placed at each of its extremities, to facilitate the operation in making the core. Upon the whole surface of the lantern, from the point h to the collet formed by the dish, a hay cord as thick as the finger is wound. Even two or more coils may be applied, as occasion requires, over which loam is spread to the exact form of the core, by applying with the hand a board, against the dish o o, with its edge cut out to the desired shape; as also against another dish, adjusted at the time towards h; while by means of the handles a rotatory movement is given to the whole apparatus.

The hay interposed between the lantern and the loam, which represents the crust of the core, aids the adhesion of the clay with the cast-iron of the lantern, and gives passage to the holes in its surface, for the air to escape through in the casting.

When the core is finished, and has been put into the drying stove, the axis g h is taken out, then the small opening which it leaves at the point h, is plugged with clay. This is done by supporting the core by the edges of the dish, in a vertical position. It is now ready to be introduced into the hollow mould of the piece.

This mould executed in baked sand consists of three pieces, two of which, absolutely similar, are represented, fig. 476, at p q, the third is shown at r s. The two similar parts p q, present each the longitudinal half of the nearly cylindrical portion of the outer surface of the gas retort; so that when they are brought together, the cylinder is formed; r s contains in its cavity the kind of hemisphere which forms the bottom of the retort. Hence, by adding this part of the mould to the end of the two others, the resulting apparatus presents in its interior, the exact mould of the outside of the retort; an empty cylindrical portion t t, whose axis is the same as that of the cylinder u u, and whose surface, if prolonged, would be everywhere distant from the surface u u, by a quantity equal to the desired thickness of the retort. The diameter of the cylinder t t is precisely equal to that of the core, which is slightly conical, in order that it may enter easily into this aperture t t, and close it very exactly when it is introduced to the collet or neck.

The three parts of the mould and the core being prepared, the two pieces p q, must first be united, and supported in an upright position; then the core must be let down into the opening t t, fig. 477. When the plate or disc o o of the core is supported upon the mould, we must see that the end of the core is everywhere equally distant from the edge of the external surface u u, and that it does not go too far beyond the line q q. Should there be an inaccuracy, we must correct it by slender iron slips placed under the edge of the disc o o; then by means of a cast-iron cross, and screw bolts v v, we fix the core immoveably. The whole apparatus is now set down upon r s, and we fix with screw bolts the plane surface q q upon r r; then introduce the melted metal by an aperture s, which has been left at the upper part of the mould.

When, instead of the example now selected, the core of the piece to be cast must go beyond the mould of the external surface, as is the case with a pipe open at each end, the thing is more simple, because we may easily adjust and fix the core by its two ends.

In casting a retort, the metal is poured into the mould set upright. It is important to maintain this position in the two last examples of casting; for all the foreign matters which may soil the metal during its flow, as the sand, the charcoal, gases, scoriæ, being less dense than it, rise constantly to the surface. The hydrostatic pressure produced by a high gate, or filling-in aperture, contributes much to secure the soundness and solidity of the casting. This gate-piece being superfluous, is knocked off almost immediately
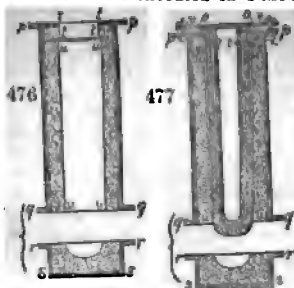
even before the casting cools. Very long, somewhat slender pieces, are usually
noulds set up obliquely to the horizon. As the metal shrinks in cooling, the
iould always be somewhat larger than the object intended to be cast. The iron
·eckons in general upon a linear shrinkage of a ninety-sixth part; that is, one eighth
:h per foot.

ig of the cast iron. — The metal is usually melted in a cupola furnace, of which
nsions are very various. *Fig.* 478 represents in plan, section, and elevation,
iese furnaces of the largest size; being capable of founding 5 tons of cast iron at
It is kindled by laying a few chips of wood upon its bottom, leaving the orifice
ind it is then filled up to the throat with coke. The fire is lit at *c*, and in a
or half an hour, when the body of fuel is sufficiently kindled, the tuyère blast is
:tion. The flame issues then by the mouth as well as the orifice *c*, which has
t open on purpose to consolidate it by the heat. Without this precaution, the
hich are made up in argillaceous sand after each day's work, would not present
ssary resistance. A quarter of an hour afterwards, the orifice *c* is closed with a
moist clay, and sometimes, when the furnace is to contain a great body of melted
ie clay is supported by means of a small plate of cast iron fixed against the

Before the blowing machine is set a going, the openings *g g g* had been kept
Those of them wanted for the tuyères are opened in succession, beginning at the
:he tuyères being raised according as the level of the fused iron stands higher in
ace. The same cupola may receive at a time from one to six tuyères, through
ie wind is propelled by the centrifugal action of an eccentric fan or ventilator.
iot appear to be ascertained whether there be any advantage in placing more
o tuyères facing each other upon opposite sides of the furnace. Their diameter
.ozzle varies from 3 to 5 inches. They are either cylindrical or slightly conical.
ihnutes after the tuyères have begun to blow, when the coke sinks in the furnace,
? charges of coke and pig iron must be thrown in. The metal begins to melt in
) minutes after its introduction; and successive charges are then made every
tes nearly; each charge containing from 2 cwts. to 5 cwts. of iron, and a quantity
onal to the estimate given below. The amount of the charges varies of course
? size of the furnace, and the speed required for the operation. The pigs must
iously broken into pieces weighing at most 14 or 16 pounds. The vanes of the
fan make from 625 to 650 turns per minute. The two cupolas represented
, and another alongside in the plan, may easily melt 6¼ tons of metal in 2¾ hours;
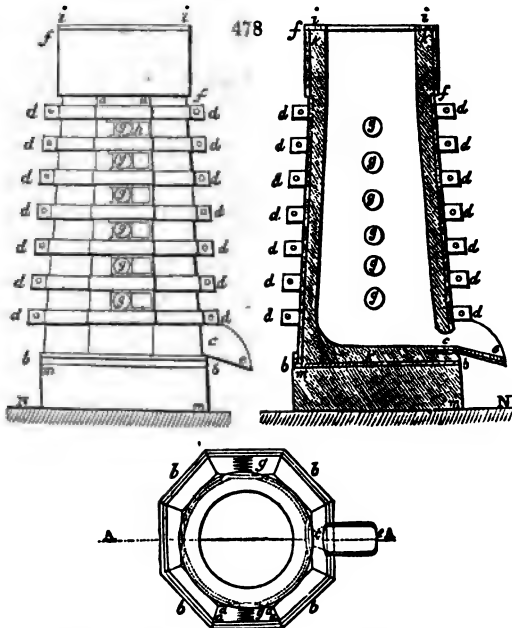
2¾ tons per hour. This result is three or four times greater than what was

formerly obtained in similar cupolas, when the blast was thrown in from small nozzle with cylinder bellows, moved by a steam engine of 10 horse power.

In the course of a year, a considerable foundry like that represented in the plate, *fig.* 467, will consume about 300 tons of coke in melting 1240 tons of cast iron; consisting of 940 tons of pigs of different qualities, and 300 tons of broken castings, gate-pieces, &c. Thus, it appears that 48 pounds of coke are consumed for melting every 2 cwt. of metal.

Somewhat less coke is consumed when the fusion is pushed more rapidly to collect a great body of melted metal, for casting heavy articles; and more is consumed when, in making many small castings, the progress of the founding has to be slackened from time to time; otherwise, the metal would remain too long in a state of fusion, and probably become too cold to afford sharp impressions of the moulds.

It sometimes happens that in the same day, with the same furnace, pieces are to be cast containing several proportions of different kinds of iron; in which case, to prevent an intermixture with the preceding or following charges, a considerable bed of coke is interposed. Though there be thus a little waste of fuel, it is compensated by the improved adaptation of the castings to their specific objects. The founding generally begins at about 3 o'clock, P. M., and goes on till 6 or 8 o'clock. One founder, aided by four laborers for charging, &c., can manage two furnaces.

The following is the work of a well-managed foundry in Derby.

200 lbs. of coke are requisite to melt, or bring down (in the language of the founder), 1 ton of cast-iron, after the cupola has been brought to its proper heat, by the combustion in it of 9 baskets of coke, weighing, by my trials, 40 pounds each, = 360 lbs.

The chief talent of the founder consists in discovering the most economical mixtures, and so compounding them as to produce the desired properties in the castings. One piece, for example, may be required to have great strength and tenacity to bear heavy weights or strains; another must yield readily to the chisel or the file; a third must resist sudden alternations of temperature; and a fourth must be pretty hard.

The filling in of the melted metal is managed in two ways. For strong pieces, whose moulds can be buried in the ground at 7 or 8 yards distance from the furnace, the metal may be run in gutters, formed in the sand of the floor, sustained by plates or stones. The clay plug is pierced with an iron rod, when all is ready.

When from the smaller size, or greater distance of the moulds, the melted metal cannot be run along the floor from the furnace, it is received in cast-iron pots or ladles, lined with a coat of loam. These are either carried by the hands of two or more men, or transported by the crane. Between the successive castings, the discharge hole of the furnace is closed with a lump of clay, applied by means of a stick, having a small disc of iron fixed at its end.

After the metal is somewhat cooled, the moulds are taken asunder, and the excrescences upon the edges of the castings are broken off with a hammer. They are afterwards more carefully trimmed or chipped by a chisel when quite cold. The loss of weight in founding is about 6½ per cent. upon the pig iron employed. Each casting always requires the melting of considerably more than its own weight of iron. This excess forms the gates, false seams, &c.; the whole of which being deducted, shows that 1 cwt. of coke is consumed for every 3 cwts. of iron put into the furnace; for every 138 cwts. of crude metal, there will be 100 cwts. of castings, 32 of refuse pieces, and 6 of waste.

Explanation of the plates.

Manner of constructing the Mould of a Sagar-pan.

Fig. 468. View of the pan.
— 469. Flat ring of cast-iron for supporting the inner mould.
— 470. Construction of the inner mould.
— 471. Formation of the outer surface of the pan.
— 472. Finished mould.
— 473. Position of the two flat cast-iron rings, destined to sustain the moulds of the inner and the outer surface.

Gas-retort Moulding.

— 474. Vertical projection, perpendicular to the axis of the retort; and two sections, the one upright, the other horizontal.
— 475. Construction of the core of the retort.
— 476. Disposition of the outer mould.
— 477. Adjustment of the core in the mould.
— 478. *Cupola furnace.* It is 3 feet wide within, and 13½ high.
m m, solid body of masonry, as a basis to the furnace.

etagonal platform of cast iron, with a ledge in which the plates *a a a a* are en-

:ight plates of cast iron, 1 inch thick, absolutely similar; only one of them is
at its lower part in *c*, to allow the melted metal to run out, and two of the others
t apertures *g g g*, &c. to admit the tuyères.
fice for letting the metal flow out.   A kind of cast iron gutter, *e*, lined with loam,
to the orifice.
ops of hammered iron, 4½ inches broad; one half of an inch thick for the bottom
id a quarter of an inch for the upper ones.   The intermediate hoops decrease in
ss from below upwards between these limits.
t iron gutter or spout, lined with loam, for running off the metal.
cylindrical piece of cast iron, for increasing the height and draught of the

e openings for receiving the tuyères, of which there are six upon each side of the
. Each of them may be shut at pleasure, by means of a small cast iron plate *h*,
slide horizontally in grooves sunk in the main plate, pierced with the holes

.aterior lining of the surface, made of sand, somewhat argillaceous, in the following
way.   After having laid at the bottom of the furnace a bed of sand a few inches thick, slightly sloped towards the orifice of discharge, there is set upright, in the axis of the cupola, a wooden cylinder of its whole height, and of a diameter a little less than that of the vacant space belonging to the top of the furnace. Sand is to be then rammed in so as to fill the whole of the furnace ;   after which the wooden cylinder is withdrawn, and the lining of sand is cut or shaved away, till it has received the proper form.

This lining lasts generally 5 or 6 weeks, when there are 6 meltings weekly.

i i, cast iron circular plate, through which the mouth of the furnace passes, for protecting the lining in *k* during the introduction of the charges.

N N, level of the floor of the foundry.   The portion of it below the running out orifice consists of sand, so that it may be readily sunk when it is wished to receive the melted metal in ladles or pots of large dimensions.

The fan distributes the blast from the main pipe to three principal points, by three branch tubes of distribution. A register, consisting of a cast-iron plate sliding with friction in a frame, serves to intercept the blast at any moment, when it is not desirable to stop the moving power. A large main pipe of zinc or sheet iron is fitted to the orifice of the slide valve. It is square at the beginning, or only rounded at the angles;

479

34
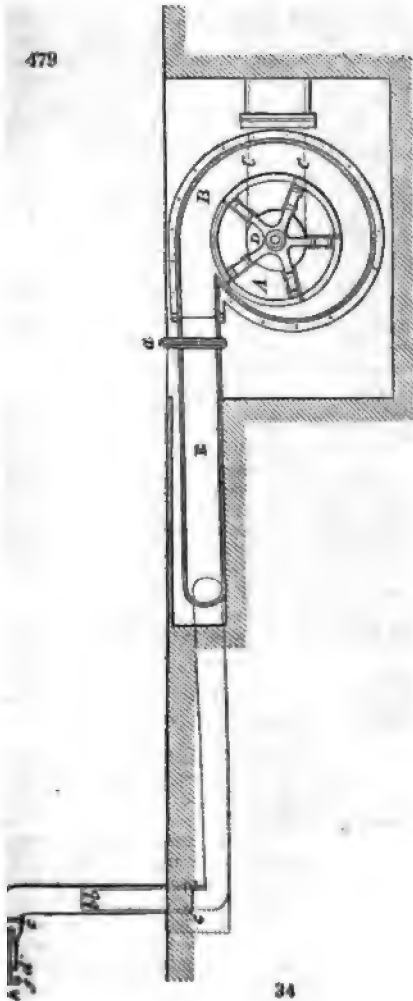
but at a little distance it becomes cylindrical, and conducts the blast to the divaricating points. There, each of the branches turns up vertically, and terminates at *b b*, *fig*. 479, where it presents a circular orifice of $7\frac{1}{2}$ inches. Upon each of the upright pipes *b*, the one end of an elbow-tube of zinc *c c c c*, *fig*. 479, is adjusted rather loosely, and the other end receives a tuyère of wrought iron *d d*, through the intervention of a shifting hose or collar of leather *c c d*, hooped with iron wire to both the tube and the tuyère. The portion *c c c* may be raised or lowered, by sliding upon the pipe *b*, in order to bring the nozzle of the tuyère *d d*, to the requisite point of the furnace. The portion *c c c c* may be made also of wrought iron. A power of 4 horses is adequate to drive this fan, for supplying blast to 3 furnaces.

The founders have observed the efflux of air was not the same when blown into the atmosphere, as it was when blown into the furnaces; the velocity of the fan, with the same impulsive power, being considerably increased in the latter case. They imagine that this circumstance arises from the blast being sucked in, so to speak, by the draught of the furnace, and that the fan then supplied a greater quantity of air.

The following experimental researches show the fallacy of this opinion. Two water syphons, *e e e*, *f f f*, made of glass tubes, one fifth of an inch in the bore, were inserted into the tuyère, containing water in the portions, *g g g*, *h h h*. The one of these manometers for measuring the pressure of the air was inserted at *k*, the other in the centre of the nozzle. The size of this glass tube was too small to obstruct in any sensible degree the outlet of the air. It was found that when the tuyères of the fan discharged into the open air, the expenditure by a nozzle of a constant diameter was proportional to the number of the revolutions of the vanes. It was further found, that when the speed of the vanes was constant, the expenditure by one or by two nozzles was proportional to the total area of these nozzles. The following formulæ give the volume of air furnished by the fan, when the number of turns and the area of the nozzles are known.

$$\text{Volume} = \frac{25 \cdot 32 \text{ S n}}{1 \cdot 000,000} \quad (1)$$

$$\text{Volume} = \frac{0 \cdot 86'6\, 7 \text{ S n}}{1,000,000} \quad (2)$$

The volume is measured at 32° Fahr., under a pressure of 29·6 inches barom.

S = is the total area of the orifices of the tuyères in square inches.

n = the number of turns of the vanes in a minute.

After measuring the speed of the vanes blowing into the atmosphere, if we introduce the nozzle of discharge into the orifice of the furnace, we shall find that their speed immediately augments in a notable degree. We might, therefore, naturally suppose that the fan furnishes more air in the second case than in the first; but a little reflection will show that it is not so. In fact, the air which issues in a cold state from the tuyère encounters instantly in the furnace a very high temperature, which expands it, and contributes, along with the solid matters with which the furnace is filled, to diminish the facility of the discharge, and consequently to retard the efflux by the nozzles. The oxygen gas consumed is replaced by a like volume of carbonic acid gas, equally expansible by heat. Reason leads us to conclude that less air flows from the nozzles into the furnace than into the open atmosphere.

The increase in the velocity of the vanes takes place precisely in the same manner, when after having made the nozzles blow into the atmosphere, we substitute for these nozzles others of a smaller diameter, instead of directing the larger ones into the furnace. Hence we may conceive that the proximity of the charged furnace acts upon the blast like the contraction of the nozzles. When the moving power is uniform, and the velocity of the vanes remains the same, the quantity of air discharged must also be the same in the two cases.

Two tuyères, one 5 inches in diameter, the other $4\frac{1}{2}$, and which, consequently, presented a total area of $35\frac{1}{2}$ square inches, discharged air into one of the furnaces, from a fan whose vanes performed 654 turns in the minute. These two nozzles being briskly withdrawn from the furnace, and turned round to the free air, while a truncated pasteboard cone of $3\frac{1}{2}$ inches diameter was substituted for the nozzle of $4\frac{1}{2}$ inches, whereby the area of efflux was reduced to 29·3 square inches, the velocity of the vanes continued exactly the same. The inverse operation having been performed, that is to say, the two original nozzles having been smartly replaced in the furnace, to discover whether or not the moving power had changed in the interval of the experiment, they betrayed no perceptible alteration of speed. From the measures taken to count the speed, the error could not exceed 3 revolutions per minute, which is altogether unimportant upon the number 654.

It follows, therefore, that when the vanes of the fan have the velocity of 654 turns per minute, the expenditure by two nozzles, whose joint area is 35½ square inches, both blowing into a furnace, is to the expenditure which takes place, when the same nozzles blow into the air, as 35·5 is to 29·3; that is, a little more than four fifths.

If this be, as is probable, a general rule for areas and speeds considerably different from the above, to find the quantity of air blown into one or more furnaces by the fan, we should calculate the volume by one of the above formulæ (1) or (2), and take four fifths of the result as the true quantity.

The fan A c here represented is of the best eccentric form, as constructed by Messrs. Braithwaite and Ericsson. D is the circular orifice round the axis by which the air is admitted; and c c B is the eccentric channel through which the air is wafted towards the main discharge pipe E.

FOUNTAIN; a stream of water rising up through the superficial strata of the earth. See ARTESIAN WELLS.

FOXING is a term employed by brewers to characterize the souring of beer, in the process of its fermentation or ripening.

FRANKFORT BLACK is made by calcining vine branches, and the other refuse lees of the vinegar vats in Germany. They must be previously washed.

FREEZING. (*Congelation*, Fr.; *Gefrierung*, Germ.) The three general forms, solid, liquid, and gaseous, under one or other of which all kinds of matter exist, seem to be immediately referable to the influence of heat; modifying, balancing, or subduing the attraction of cohesion. Every solid may be liquefied, and every liquid may be vaporized, by a certain infusion of caloric, whether this be regarded as a moving power or an elastic essence. The converse of this proposition is equally true; for many gases, till lately styled permanent, may be liquefied, nay, even solidified, by diminution of their temperature, either alone, or aided by a condensing force, to bring their particles within the sphere of aggregative attraction. When a solid is transformed into a liquid, and a liquid into a gas or vapor, a quantity more or less considerable of heat is absorbed, or becomes latent, to use the term of Dr. Black, the celebrated discoverer of this great law of nature. When the opposite transformation takes place, the heat absorbed is again emitted, or what was latent becomes sensible caloric. Upon the first principle, or the absorption of heat, are founded the various artificial methods of producing cold and congelation.

Tables exhibiting a collective view of all the Frigorific Mixtures contained in Mr. Walker's publication, 1808.

I.—Table consisting of Frigorific Mixtures, composed of ice, with chemical salts and acids.

Frigorific Mixtures with Ice.

MIXTURES.		Thermometer sinks.	Degree of cold produced.
Snow, or pounded ice - 2 parts Muriate of soda - - 1		to — 5°	•
Snow, or pounded ice - 5 parts Muriate of soda - - 2 Muriate of ammonia - - 1	From any temperature	to — 12°	•
Snow, or pounded ice - 24 parts Muriate of soda - 10 Muriate of ammonia - 5 Nitrate of potash - 5		to — 18°	•
Snow, or pounded ice - 12 parts Muriate of soda - 5 Nitrate of ammonia - 5		to — 25°	•
Snow - - - 3 parts Diluted sulphuric acid - 2		From + 32° to — 23°	55
Snow - - - 8 parts Muriatic acid - 5		From + 32° to — 27°	59
Snow - - - 7 parts Diluted nitric acid - 4		From + 32° to — 30°	62
Snow - - - 4 parts Muriate of lime - 5		From + 32° to — 40°	72
Snow - - - 2 parts Cryst. muriate of lime - 3		From + 32° to — 50°	82
Snow - - - 3 parts Potash - - - 4		From + 32° to — 51°	83

N. B.—The reason for the omissions in the last column of the preceding table is, the thermometer sinking in these mixtures to the degree mentioned in the preceding column, and never lower, whatever may be the temperature of the materials at mixing.

II.—Table, consisting of Frigorific Mixtures, having the power of generating or creating cold, without the aid of ice, sufficient for all useful and philosophical purposes, in any part of the world at any season.

Frigorific Mixtures without Ice.

MIXTURES.		Thermometer sinks.	Degree of cold produced.
Muriate of ammonia	- 5 parts	From + 50° to + 10°.	40°
Nitrate of potash	- 5		
Water	- 16		
Muriate of ammonia	- 5 parts	From + 50° to + 4°	46
Nitrate of potash	- 5		
Sulphate of soda	- 8		
Water	- 16		
Nitrate of ammonia	- 1 part	From + 50° to + 4°	46
Water	- 1		
Nitrate of ammonia	- 1 part	From + 50° to — 7°	57
Carbonate of soda	- 1		
Water	- 1		
Sulphate of soda	- 3 parts	From + 50° to — 3°	53
Diluted nitric acid	- 2		
Sulphate of soda	- 6 parts	From + 50° to — 10°	60
Muriate of ammonia	- 4		
Nitrate of potash	- 2		
Diluted nitric acid	- 4		
Sulphate of soda	- 6 parts	From + 50° to — 14°	64
Nitrate of ammonia	- 5		
Diluted nitric acid	- 4		
Phosphate of soda	- 9 parts	From + 50° to — 12°	62
Diluted nitric acid	- 4		
Phosphate of soda	- 9 parts	From + 50° to — 21°	71
Nitrate of ammonia	- 6		
Diluted nitric acid	- 4		
Sulphate of soda	- 8 parts	From + 50° to 0°	50
Muriatic acid	- 5		
Sulphate of soda	- 5 parts	From + 50 to + 3°	47
Diluted sulphuric acid	- 4		

N. B.—If the materials are mixed at a warmer temperature than that expressed in the table, the effect will be proportionably greater; thus, if the most powerful of these mixtures be made when the air is + 85°, it will sink the thermometer to + 2°.

III.—Table consisting of Frigorific Mixtures selected from the foregoing Tables, and combined so as to increase or extend cold to the extremest degrees.

Combinations of Frigorific Mixtures.

MIXTURES.		Thermometer sinks.	Degree of cold produced.
Phosphate of soda	- 5 parts	From 0° to — 34°	34°
Nitrate of ammonia	- 3		
Diluted nitric acid	- 4		
Phosphate of soda	- 3 parts	From — 34° to — 50°	16
Nitrate of ammonia	- 2		
Diluted mixed acids	- 4		
Snow	- 3 parts	From 0° to — 46°	46
Diluted nitric acid	- 2		

TABLE III.—*continued.*

MIXTURES.		Thermometer sinks.	Deg. of cold produced.
- - - - 8 parts phuric acid - 3 ric acid - - 3		From — 10° to — 56°	46
- - - - 1 part lphuric acid - - 1		From — 20° to — 60°	40
- - - - 3 parts lime - - 4		From + 20° to — 48°	68
- - - - 3 parts lime - - 4		From + 10° to — 54°	64
- - - - 2 parts lime - . - 3		From — 15° to — 68°	53
- - - - 1 part riate of lime - - 2		From 0° to — 66°	66
- - - - 1 part riate of lime - - 3		From — 40° to — 73°	33
- - - - 8 parts lphuric acid - - 10		From — 68° to — 91°	23

ie materials in the first column are to be cooled, previously to mixing, to the
required, by mixtures taken from either of the preceding tables.
orbs 1000 degrees of heat in becoming vapor; whence, if placed in a saucer
hausted-receiver, over a basin containing strong sulphuric acid, it will freeze
absorption of its heat into the vapor so copiously formed under these circum-

ost powerful means of artificial refrigeration is afforded by the evaporation
arbonic acid gas; for the frozen carbonic acid thus obtained has probably a
100° under zero; so that when a piece of it is laid upon quicksilver, it in-
als this metal. The more copious discussion of this subject belongs to
ince.

BERRIES; Berries of Avignon.

N, counteraction of; see LUBRICATION.

e ENAMEL and GLASS.

ombustible, Fr.; Brennstoff, Germ.).

ustibles as are used for fires or furnaces are called fuel, as wood, turf, pit-
differ in their nature and in their power of giving heat.

which is divided into hard and soft. To the former belong the oak, the
der, the birch, and the elm; to the latter, the fir, the pine of different sorts,
linden, the willow, and the poplar.

e dryness and weight different woods are found to afford equal degrees of
ustion. Moisture diminishes the heating power in three ways; by diminish-
ive weight of the ligneous matter, by wasting heat in its evaporation, and
ow and imperfect combustion. If a piece of wood contain, for example, 25
water, then it contains only 75 per cent. of fuel, and the evaporation of that
quire $\frac{1}{28}$ part of the weight of the wood. Hence the damp wood is of less
bustion by $\frac{8}{28}$ or $\frac{2}{7}$ than the dry. The quantity of moisture in newly felled
ts to from 20 to 50 per cent.; birch contains 30, oak 35, beech and pine 39,
45. According to their different natures, woods which have been felled and
nonths contain still from 20 to 25 per cent. of water. There is never less
cent. present, even when it has been kept long in a dry place, and though it
strong heat, it will afterwards absorb 10 or 12 per cent. of water. If it be
kiln dried, its heating powers are impaired by the commencement of carbon-
f some of its hydrogen were destroyed. It may be assumed as a mean of
mental results, that 1 pound of artificially dried wood will heat 35 pounds
m the freezing to the boiling point; and that a pound of such wood as con-
) to 25 per cent. of water will heat 26 pounds of ice-cold water to the same
s better to buy wood by measure than by weight, as the bulk is very little
moisture. The value of different woods for fuel is inversely as their mois-
s may easily be ascertained by taking their shavings, drying them in a heat
nd seeing how much weight they lose.

y combustible the heat is diffused either by radiation or by direct communi-
ies in contact with the flame. In a wood fire the quantity of radiating heat
fused by the air as 1 to 3; or it is one fourth of the whole heating power

II. *Charcoal.* The different charcoals afford, under equal weights, equal quantities of heat. We may reckon, upon an average, that a pound of dry charcoal is capable of heating 73 pounds of water from the freezing to the boiling point; but when it has been for some time exposed to the air, it contains at least 10 per cent. of water, which is partially decomposed in the combustion into carbureted hydrogen, which causes flame, whereas pure dry charcoal emits none.

A cubic foot of charcoal from soft wood weighs, upon an average, from 8 to 9 pounds, and from hard wood 12 to 13 pounds; and hence the latter are best adapted to maintain a high heat in a small compass. The radiating heat from charcoal fires constitutes one third of the whole emitted.

III. *Pitcoal.* The varieties of this coal are almost indefinite, and give out very various quantities of heat in their combustion. The carbon is the heat-giving constituent, and it amounts, in different coals, to from 75 to 95 per cent. One pound of good pitcoal will, upon an average, heat 60 pounds of water from the freezing to the boiling point. Small coal gives out three fourths of the heat of the larger lumps. The radiating heat emitted by burning pitcoal is greater than that by charcoal.

IV. *The coke of pitcoal.*—The heating power of good coke is to that of pitcoal as 75 to 69. One pound of the former will heat 65 pounds of water from 32° to 212°; so that its power is equal to nine tenths of that of wood charcoal.

V. *Turf or peat.*—One pound of this fuel will heat from 25 to 30 pounds of water from freezing to boiling. Its value depends upon its compactness and freedom from earthy particles; and its radiating power is to the whole heat it emits in burning as 1 to 3.

VI. *Carbureted hydrogen or coal gas.*—One pound of this gas, equal to about 24 cubic feet, disengages, in burning, as much heat as will raise 76 pounds of water from the freezing to the boiling temperature.

In the following table the fourth column contains the weight of atmospherical air, whose oxygen is required for the complete combustion of a pound of each particular substance.

Species of combustible.	Pounds of water which a pound can heat from 0° to 212°.	Pounds of boiling water evaporated by 1 pound.	Weight of atmospheric air at 32°, to burn 1 pound.
Perfectly dry wood -	35·00	6·36	5·96
Wood in its ordinary state	26·00	4·72	4·47
Wood charcoal - -	73·00	13·27	11·46
Pitcoal - - -	60·00	10·90	9·26
Coke - - -	65·00	11·81	11·46
Turf - - -	30·00	5·45	4·60
Turf charcoal - -	64·00	11·63	9·86
Carbureted hydrogen gas -	76·00	13·81	14·58
Oil ⎫ Wax ⎬ - -	78·00	14·18	15·00
Tallow ⎭			
Alcohol of the shops -	52·60	9·56	11·60

The quantity of air stated in the fourth column is the smallest possible required to burn the combustible, and is greatly less than would be necessary in practice, where much of the air never comes into contact with the burning body, and where it consequently never has its whole oxygen consumed. The heating power stated in the second column is also the maximum effect, and can seldom be realized with ordinary boilers. The draught of air usually carries off at least $\frac{1}{7}$ of the heat, and more if its temperature be very high when it leaves the vessel. In this case it may amount to one half of the whole heat or more; without reckoning the loss by radiation and conduction, which, however, may be rendered very small by enclosing the fire and flues within proper non-conducting and non-radiating materials.

It appears that, in practice, the quantity of heat which may be obtained from any combustible in a properly mounted apparatus must vary with the nature of the object to be heated. In heating chambers by stoves, and water boilers by furnaces, the effluent heat in the chimney which constitutes the principal waste may be reduced to a very moderate quantity, in comparison of that which escapes from the best constructed reverberatory hearth. In heating the boilers of steam engines, one pound of coal is reckoned adequate to convert $7\frac{1}{2}$ pounds of boiling water into vapor; or to heat $41\frac{1}{4}$ pounds of water from the freezing to the boiling point. One pound of fir of the usual dryness will evaporate 4 pounds of water, or heat 22 pounds to the boiling temperature; which is about two thirds of the maximum effect of this combustible. According to Watt's experiments upon the great scale, one pound of coal can boil off, with the best built boiler, 9 pounds of water; the deficiency from the maximum effect being here $\frac{10}{57}$, or nearly one sixth.

In many cases, the hot air which passes into the flues or chimneys may be bene-

the heating, drying, or roasting of objects; but care ought to be taken
)f the fire be not thereby impaired, and an imperfect combustion of the
For at a low smothering temperature both carbonic oxyde and carburet-
· be generated from coal, without the production of much heat in the

:xactly the quantity of heat disengaged by any combustible in the act
different systems of apparatus have been employed : 1. the calorimeter
Laplace, in which the substance is burned in the centre of a vessel, whose
ith ice ; and the amount of ice melted, measures the heat evolved ; 2. the
att and Rumford, in which the degree of heat communicated to a given
irds the measure of temperature ; and 3. by the quantity of water evap-
t kinds of fuel in similar circumstances.
: to ascertain the relative heating powers of different kinds of fuel, we
much about the total waste of heat in the experiments, provided it be
and therefore they should be burned in the same furnace, and in the
the more economically the heat is applied, the greater certainty will
there be in the results. The apparatus *fig.* 480,
is simple and well adapted to make such com-
parative trials of fuel. The little furnace is
covered at top, and transmits its burned air by *c*,
through a spiral tube immersed in a cistern of
water, having a thermometer inserted near its
top, and another near its bottom, into little side
orifices *a a*, while the effluent air escapes from the
upright end of the tube *b*. Here also a ther-
mometer bulb may be placed. The average in-
dication of the two thermometers gives the mean
temperature of the water. As the water evapo-
rates from the cistern, it is supplied from a vessel
placed alongside of it. The experiment should be
begun when the furnace has acquired an equa-
.ture. A throttle valve at *c* serves to regulate the draught, and to
e different experiments by means of the temperature of the effluent
vater has been heated the given number of degrees, which should be
different experiments, the fire may be extinguished, the remaining fuel
ipared with the original quantity. Care should be taken to make the
·id and free from smoke as possible.
)N designates the sudden brightening of the melted gold and silver
e assayer, when the last film of vitreous lead and copper leaves their
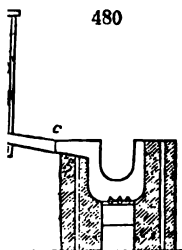
480

ARTH (*Terre à foulon*, *Argile Smectique*, Fr.; *Walkererde*, Germ.)
coarse or fine grained mass of lithomarge clay. Its color is green-
gray ; it is dull, but assumes a fatty lustre upon pressure with the
uous, does not adhere to the tongue, and has a specific gravity varying
). It falls down readily in water, into a fine powder, with extrication
nd forms a non-plastic paste. It melts at a high heat into a brown
uents are 53·0 silica; 10·0 alumina; 9·75 red oxyde of iron; 1·25
ne ; 24 water, with a trace of potash. Its cleansing action upon wool-
upon its power of absorbing greasy matters. It should be neither te-
f; for in the first case, it would not diffuse itself well through water,
l it would abrade the cloth too much. The finely divided silica is one
dients.
is found in several counties of England; but in greatest abundance in
kshire, Hampshire, and Surry.
)f Surry there are great quantities of fuller's earth found about Nut-
d Blechingley, to the south of the Downs, and some, but of inferior
ton and Croydon, to the north of them. The most considerable pits
, between which place and Ryegate, particularly on Redhill, about a
f Ryegate, it lies so near the surface as frequently to be turned up by
: wagons. The fuller's earth to the north of the road between Red-
and about a quarter of a mile from the latter place, is very thin; the
is thickest on the swell of the hill to the south of the road. It is not
this earth has been dug in Surry; the oldest pit now wrought is said
.ween 50 and 60 years, but it is fast wearing out. The seam of fuller's
erent directions. In one, if not in more cases, it inclines to the west
ıle angle. There are two kinds of it, the blue and the yellow; the
ıstern side of the pit, is frequently within a yard of the surface, being

covered merely with the soil—a tough, wet, clayey loam. A few yards to the west, the blue kind appears with an irony sand-stone, of nearly two yards in thickness, between it and the soil. The blue earth in this pit is nearly 16 feet deep. In some places the yellow kind is found lying upon the blue ; there seems, indeed, to be no regularity either in the position or inclination of the strata where the fuller's earth is found, nor any mark by which its presence could be detected. It seems rather thrown in patches than laid in any continued or regular vein. In the midst of the fuller's earth are often found large pieces of stone of a yellow color, translucent and remarkably heavy, which have been found to be sulphate of barytes, encrusted with quartzose crystals. These are carefully removed from the fuller's earth, as the workmen say they often spoil many tons of it which lie about them. There is also found with the yellow fuller's earth a dark brown crust, which the workmen consider as injurious also. In Surry the price of fuller's earth seems to have varied very little, at least for these last 80 years. In 1730, the price at the pit was 6d. a sack, and 6s. per load or ton. In 1744, it was nearly the same. It is carried in wagons, each drawing from three to four tons, to the beginning of the iron railway near Westham, along which it is taken to the banks of the Thames, where it is sold at the different wharves for about 25s. or 26s. per ton. It is then shipped off either to the north or west of England.

The next characteristic stratum, owing to its forming a ridge of conspicuous hills through the country, is the Woburn land, a thick ferruginous stratum, which below its middle contains a stratum of fuller's earth. This is thicker and more pure in Aspley and Hogstye-end, two miles north-west of Woburn, than in any known place.

Fuller's earth is found at Tillington, and consumed in the neighboring fulling mills.

Mode of preparing fuller's earth :—

After baking it is thrown into cold water, where it falls into powder, and the separation of the coarse from the fine is effectually accomplished, by a simple method used in the dry color manufactories, called washing over. It is done in the following manner: Three or four tubs are connected on a line by spouts from their tops ; in the first the earth is beat and stirred, and the water, which is continually running from the first to the last through intermediate ones, carries with it and deposites the fine whilst the coarse settles in the first. The advantages to be derived from this operation are, that the two kinds will be much fitter for their respective purposes of cleansing coarse or fine cloth; for without baking the earth they would be unfit, as before noticed, to incorporate so minutely with the water in its native state ; it would neither so readily fall down, nor so easily be divided into different qualities, without the process of washing over. When fuel is scarce for baking the earth, it is broken into pieces of the same size, as mentioned above, and then exposed to the heat of the sun.

The various uses of fuller's earth may be shortly explained. According to the above method, the coarse and fine of one pit being separated, the first is used for cloths of an inferior, and the second for those of a superior quality. The yellow and the blue earths of Surry are of different qualities naturally, and are, like the above, obtained artificially, and used for different purposes. The former, which is deemed the best, is employed in fulling the kerseymeres and finer cloths of Wiltshire and Gloucestershire, whilst the blue is principally sent into Yorkshire for the coarser cloths. Its effect on these cloths is owing to the affinity which alumine has for greasy substances ; it unites readily with them, and forms combinations which easily attach themselves to different stuffs, and thereby serve the purpose of mordants in some measure. The fullers generally apply it before they use the soap.

FULLING; for the theory of the process, see FELTING and WOOL.

FULLING MILL. Willan and Ogle obtained a patent in 1825 for improved fulling machinery, designed to act in a similar way to the ordinary stocks, in which cloths are beaten, for the purpose of washing and thickening them ; but the standard and the bed of the stocks are made of iron instead of wood as heretofore ; and a steam vessel is placed under the bed, for heating the cloths during the operation of fulling; whereby their appearance is said to be greatly improved.
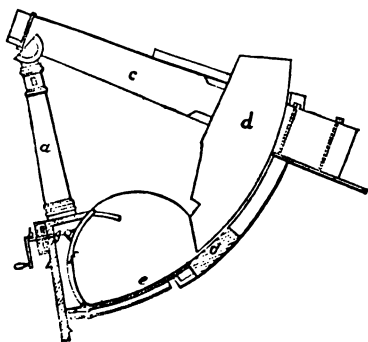
Fig. 480° is a section of the fulling machine or stocks; *a* is a cast-iron pillar, made hollow for the sake of lightness; *b* is the bed of the stocks, made also of iron, and polished smooth, the side of the stock being removed to show the interior; *c* is the lever that carries the beater *d*. The cloths are to be placed on the bed *b*, a

480°

bottom, and water allowed to pass through the stock, when by the repeated blows of the beater *d*, which is raised and let fall in the usual way, the cloths are beaten, and become cleansed and fulled.

A part of the bed at *e*, is made hollow, for the purpose of forming a steam box, into which steam from a boiler is introduced by a pipe with a stop-cock. This steam heats the bed of the stock, and greatly facilitates, as well as improves the process of cleansing and fulling the cloths.

The smoothness of the surface of the polished metal, of which the bed of the stock is constituted, is said to be very much preferable to the roughness of the surface of wood of which ordinary fulling stocks are made, as by these iron stocks less of the nap or felt of the cloth is removed, and its appearance when finished is very much superior to cloths fulled in ordinary stocks.

In the operation of fulling, the cloths are turned over on the bed, by the falling of the beaters, but this turning over of the cloths will depend in a great measure upon the form of the front or breast of the stock. In these improved stocks, therefore, there is a contrivance by which the form of the front may be varied at pleasure, in order to suit cloths of different qualities; *f*, is a moveable curved plate, constituting the front of the stock; its lower part is a cylindrical rod, extending along the entire width of the bed, and being fitted into a recess, forms a hinge joint upon which the curved plate moves; *g*, is a rod attached to the back of the curved plate *f*, with a screw thread upon it; this rod passes through a nut *h*, and by turning this nut, the rod is moved backward or forward, and consequently the position of the curved plate altered.

The nut *h*, is a wheel with teeth, taking into two other similar toothed wheels, one on each side of it, which are likewise the nuts of similar rods jointed to the back of the curved plate *f*; by turning the central wheel, therefore, which may be done by a winch, the other two wheels are turned also, and the curved plate moved backward or forward. At the upper part of the plate there are pins passing through curved slots, which act as guides when the plate is moved.

The patentees state in conclusion, that steam has been employed before for heating cloths while fulling them, they therefore do not exclusively claim its use, except in the particular way described; the advantages arising from the construction of iron stocks, with polished surfaces in place of wooden ones, together with the moveable curved plates described, are in their opinion "sufficiently important to constitute a patent right."

FULMINATES, or *fulminating powders.* Of these explosive compounds, there are several species; such as fulminating gold, mercury, platinum, silver; besides the old fusible mixture of nitre, sulphur, and potash. The only kind at all interesting in a manufacturing point of view is the fulminate of mercury, now so extensively used as a priming to the caps of percussion locks. Having published a paper in the Journal of the Royal Institution for 1831, upon gunpowder (see GUNPOWDER), the result of an elaborate suite of experiments, I was soon afterwards requested by the Hon. the Board of Ordnance to make such researches as would enable me to answer, in a satisfactory practical manner, a series of questions upon fulminating powders, subservient to the future introduction of percussion muskets into the British army. The following is a verbatim copy of my report upon the subject :—

To the Secretary of the Board of Ordnance.

"SIR,—I have the honor of informing you, for the instruction of the Honorable the Master General and the Board of Ordnance, that the researches on fulminating mercury, which I undertook by their desire, have been brought to a satisfactory conclusion, after a numerous, diversified, and somewhat hazardous series of experiments. The following are the questions submitted to me, with their respective answers :—

Question 1. What proportions of mercury, with nitric acid and alcohol of certain strengths, will yield the greatest quantity of pure fulminate of mercury ?

Answer. One hundred parts, by weight, of mercury, must be dissolved with a gentle heat, in 1000 parts (also by weight) of nitric acid, spec. gr. 1·4; and this solution, at the temperature of about 130° Fahr., must be poured into 830 parts by weight of alcohol, spec. gr. 0·830.—*Note.* 830 parts of such alcohol, by weight, constitute 1000 by measure; and 1000 parts of such nitric acid, by weight, constitute 740 by measure. Hence, in round numbers, one ounce weight of quicksilver must be dissolved in 7½ oz. measures of the above designated nitric acid, and the resulting solution must be poured into 10 oz. measures of the said alcohol.

Question 2. What is the most economical and safe process for conducting the manipulation, either as regards the loss of nitrous gas and residuum, or as respects danger to the operator; also, what is the readiest and safest mode of mixing the fulminate intimately with its due proportions of common gunpowder.

Answer. The mercury should be dissolved in the acid in a glass retort, the beak of which is loosely inserted into a large balloon or bottle of glass or earthenware, whereby

the offensive fumes of the nitrous gas disengaged during the solution, are, in a consider able measure, condensed into liquid acid, which should be returned into the retort. As soon as the mercury is all dissolved, and the solution has acquired the prescribed temperature of about 130°, it should be slowly poured, through a glass or porcelain funnel, into the alcohol contained in a glass matrass or bottle capable of holding fully 6 times the bulk of the mixed liquids. In a few minutes bubbles of gas will proceed from the bottom of the liquid; these will gradually increase in number and magnitude till a general fermentative commotion, of a very active kind, is generated, and the mixture assumes a somewhat frothy appearance. A white voluminous gas now issues from the orifice of the matrass, which is very combustible, and must be suffered to escape freely into the air, at a distance from any flame. These fumes consist of an ethereous gas, holding mercury in suspension or combination. I have made many experiments with the view of condensing this gas, or, at least, the mercury, but with manifest disadvantage to the perfection of the process of producing fulminate. When the said gas is transmitted, through a glass tube, into a watery solution of carbonate of soda, a little oxyde of mercury is, no doubt, recovered; but the pressure on the fermentative mixture, though slight, necessary to the displacement of the soda solution, seems to obstruct or impair the generation of the fulminate; this effect is chiefly injurious towards the end of the operation, when the gaseous fumes are strongly impregnated with nitrous gas. When this is not allowed freely to come off, a portion of subnitrate or nitrate of mercury is apt to be formed, to the injury of the general process and the product.

As soon as the effervescence and concomitant emission of gas are observed to cease, the contents of the matrass should be turned out upon a paper double filter, fitted into a glass or porcelain funnel, and washed by the affusion of cold water till the drainings no longer redden litmus paper. The powder adhering to the matrass should be washed out and thrown on the filter by the help of a little water. Whenever the filter is thoroughly drained, it is to be lifted out of the funnel, and opened out on plated copper or stone ware, heated to 212° Fahr. by steam or hot water. The fulminate. being thus dried. is to be put up in paper parcels of about 100 grains each; the whole of which may be afterwards packed away in a tight box, or a bottle with a cork stopper. The excellence of the fulminate may be ascertained by the following characters. It consists of brownish-gray small crystals which sparkle in the sun, are transparent when applied to a slip of glass with a drop of water, and viewed by transmitted light. These minute spangles are entirely soluble in 130 times their weight of boiling water; that is to say, an imperial pint of boiling water will dissolve 67 grs. of pure fulminate. Whatever remains indicates impurity. From that solution beautiful pearly spangles of fulminate fall down as the liquid cools.

It may now be proper to show within what nice and narrow limits the best proportions of the ingredients used in making the fulminate of mercury lie. The following are selected from among many experiments instituted to determine that point, as well as the most economical process.

1. According to the formula given by the celebrated chemist Berzelius, in the 4th vol. of his "Traité de Chimie," recently published (p. 383), the mercury should be dissolved in 12 times its weight of nitric acid, sp. gr. 1·375; and alcohol of sp. gr. 0·850, amounting to 16·3 times the weight of the mercury, should be poured at intervals into the nitric solution. The mixture is then to be heated till effervescence with the characteristic cloud of gas appears. On the action becoming violent, alcohol is to be poured in from time to time to repress it, till additional 16.3 parts have been employed.

On this process I may remark, that it is expensive, troublesome, dangerous, and unproductive of genuine pure fulminate. One fifth more nitric acid is expended very nearly than what is necessary, and almost four times the weight of alcohol which is beneficial. Of alcohol at 0·83, 8·3 parts by weight are sufficient; whereas Berzelius prescribes nearly 4 times this quantity in weight, though the alcohol is somewhat weaker, being of sp. gr. 0·850. By using such an excess of alcohol, much of the fulminate is apt to be revived into globules of quicksilver at the end of the process, as I showed in my paper on this subject published in the Journal of the Royal Institution two years ago. There is no little hazard in pouring the alcohol into the nitric solution; for at each affusion an explosive blast takes place, whereas by pouring the solution into the alcohol, as originally enjoined by the Hon. Mr. Howard, the inventor of the process, no danger whatever is incurred. 100 parts of mercury treated in the way recommended by Berzelius afforded me only 112 parts of fulminate, instead of the 130 obtained by my much more economical and safe proportions and process from the same weight of quicksilver.

2. If 10 parts of nitric acid of sp. gr. 1·375 be used for dissolving 1 of quicksilver, and if 14 parts of alcohol of sp. gr. 0·85 be thereafter mixed with the solution, the product of such proportions will either be not granular, and therefore not fulminating, or

will be partially granular and partially pulverulent, being a mixture of fulminate and bnitrate of mercury ill adapted for priming detonating caps. Instead of 130 parts of nuine fulminate, as I do obtain, probably not more than 10 parts of powder will be oduced, and that of indifferent quality. In fact, whenever the ethereous fermentation defective, or not vigorous, little true fulminate is generated; but much of the mercury mains in the acidulated alcoholic liquid.

3. If the alcohol be poured in successive portions, and of proper strength (sp. gr. 0·83), to a proper nitric solution of mercury, the explosive action which accompanies each fusion dissipates much of the alcohol, and probably impairs the acid, so that the subquent ethereous fermentation is defective, and little good fulminate is formed. From 10 parts of mercury submitted to this treatment, I obtained in one experiment, carefully ade, only 51 parts of a powder, which was impalpable, had a cream color, and was not plosive either by heat or percussion.

4. When, with 100 parts of mercury, 800 of nitric acid of sp. gr. 1·375, are employed ith 650 of alcohol of sp. gr. ·846, no fulminate whatever is generated.

5. When, with the proper proportions of mercury, acid, and alcohol, the process is lvanced into a proper energy of fermentative commotion, if the matrass be immersed in ld water so as materially to repress that action, the process will be impaired, and will rn out ultimately defective both as to the quantity and quality of the fulminate. It is erefore evident that a certain energy or vivacity of etherization is essential to the full ecess of this curious process, and that anything which checks it, or obstructs its taking ace, is injurious and to be avoided.

When my proportions are observed in making fulminating mercury, somewhat less an one fourth of the nitric acid used in making the solution remains in the alcoholic xture along with the fulminate. When other proportions are taken, much more acid mains. This acid is not recoverable to any useful or economical purpose, nor is the ?ohol that is associated with it. Many distillations, with various reagents, have led me this practical conclusion. In fact, when the process is most complete, as described in e first paragraph, the alcohol is entirely and profitably employed in etherization, an nerating fulminic acid.

I have made a series of analytical experiments on the pure fulminate of mercury, with e view of determining its composition, the quantity of quicksilver present in it, and nsequently the loss of mercury in the operation. I have stated that my maximum proet of fulminate from 100 grs. of quicksilver is 130 grs. Occasionally, from slight differences in the temperature of the mixture, or the ambient atmosphere, 2 grs. less may obtained.

A. I dissolved 130 grs. with a gentle heat in muriatic acid contained in a small matrass, ding a few drops of the nitric to quicken the solution. On evaporating it to dryness, th much care to avoid volatilization of the salt, I obtained 125 grs. of corrosive subate or bi-chloride of mercury. But 125 grs. of this bi-chloride contain only 91·1 . of quicksilver. Therefore, by this experiment, 130 grs. of fulminate contain no re than 91·1 of mercury, indicating an exhalation of 8·9 parts in the form of fumes, a retention in the residuary liquid of some of these 8·9 parts, out of the 100 originally ployed.

B. In another experiment for analysis, 130 grs. dissolved as above, were thrown wn by carbonate of soda. 95 grs. of black oxyde of mercury were obtained, which ? equivalent to 91·2 grs. of quicksilver; affording a confirmation of the preceding ult.

C. 130 grs. of fulminate were dissolved in strong muriatic acid, and the solution was composed by crystals of proto-muriate of tin at a boiling temperature. The mercury u precipitated in globules to such amount as to verify the two preceding experents.

Regarding fulminate of mercury as a bi-cyanate, that is, as a compound of one atom one equivalent prime of deutoxyde of mercury, and two primes of cyanic acid, we shall d its theoretical composition to be as follows, hydrogen being the radix, or 1.

$$\begin{array}{lcc} \text{2 Primes of Cyanic or fulminic Acid} = 34 \times 2 = 68 & & 24 \\ \text{Deutoxyde of Mercury} = & 216 & 76 \\ \hline & 284 & 100 \end{array}$$

As these 284 parts of fulminate contain 200 of quicksilver, so 142 parts of fulminate ll contain 100 of quicksilver. Whence it appears, that when only 130 parts of fulate can be obtained in practice from 100 of quicksilver, 8½ parts of quicksilver out the 100 are unproductive, that is, are expended in the etherized gas, or left in the iduary acidulous liquid. By the above experimental and theoretical analysis, 91·5 rts of quicksilver enter into the composition of 130 parts of true crystalline fulminate. e complete accordance here exhibited between theory and practice removes every

shadow of doubt as to the accuracy of the statements. 100 parts of fulminate consist of—

$$\left.\begin{array}{l}\text{Mercury} \quad 70\cdot4 \\ \text{Oxygen} \qquad 5\cdot6\end{array}\right\} \text{Peroxyde } 76\cdot0$$

Fulminic acid -   -   24

100·0

Question 3. May the gas or vapor produced by the inflammation of the fulminate of mercury, when combined with a portion of gunpowder, be considered in its nature corrosive of iron or brass?

Answer. I have suggested to Mr. Lovell, of Waltham Abbey works, that the fulminate may be probably diluted most advantageously with spirit varnish made of a proper consistence by dissolving sandarach in alcohol. When well mixed with this varnish, a small drop of the mixture will suffice for priming each copper cap or disc; and as the spirit evaporates immediately, the fulminate will be fixed to the copper beyond the risk of shaking or washing away. On the Continent, tincture of benjamin is used for the same purpose; but as that balsamic resin leaves in combustion a voluminous coal, which sandarach does not, the latter, which is the main constituent of spirit varnish, seems better adapted for this purpose. It is sufficiently combustible, and may be yet made, by a due proportion, to soften the violence of the explosive mercury on the nipple of the touch-hole. Fulminate prepared by my formula has no corrosive influence whatsoever on iron or steel; and, therefore, if such a medium of applying it, as I have now taken leave to suggest, should be found to answer, all fears on the score of corrosion may for ever be set at rest.

Question 4. How far is the mixture (of fulminate and gunpowder) liable to be affected by the moisture of the atmosphere, or by the intrusion of water; and will such an accident affect its inflammability when dried again?

Answer. Well made fulminate, mixed with gunpowder and moistened, undergoes no change, nor is it apt to get deteriorated by keeping any length of time in a damp climate or a hazy atmosphere. Immersion in water would be apt to wash the nitre out of the pulverine; but this result would be prevented if the match or priming mixture were liquefied or brought to the pasty consistence, not with water, but spirit varnish. Such detonating caps would be indestructible, and might be alternately moistened and dried without injury.

Question 5. Is it at all probable that the composition would be rendered more inflammable or dangerous of use by the heat of tropical climates?

Answer. No elevation of temperature of an atmospheric kind, compatible with human existence, could cause spontaneous combustion of the fulminating mercury, or the detonating matches made with it. In fact, its explosive temperature is so high as 367° of Fahrenheit's scale, and no inferior heat will cause its detonation.

Question 6. Is the mercurial vapor or gas arising from the ignition of a great number of primers, and combined with the smoke of gunpowder in a confined space (as in the case of troops in close bodies, squares, casemates, &c.), likely in its nature to be found prejudicial to human health?

Answer. I have exploded in rapid succession of portions, 100 grains of fulminate of mercury (equivalent to 300 or 400 primers), in a close chamber of small dimensions, without experiencing the slightest inconvenience at the period, or afterwards, though my head was surrounded by the vapors all the time of the operation. These vapors are, in fact, so heavy that they subside almost immediately. When the fulminate mixed with pulverine is exploded in the primers by condensed masses of troops, the mercury will cause no injury to their health, nor 100th part of the deleterious impression on weak lungs which the gases of exploded gunpowder might by possibility inflict. These gases are all, *theoretically* speaking, noxious to respiration; such as carbonic acid gas, azote, carbureted hydrogen, and sulphureted hydrogen, a deadly gas. Yet the soldier who should betray any fear of gunpowder smoke would be an object of just ridicule."

In the following September, I executed for the Board of Ordnance a set of experiments, complementary to those of the memoir, with the view of ascertaining the best manner of protecting the fulminate when applied to the copper caps, from being detached by carriage, or altered by keeping. The following were my results and conclusions.

"1. Fulminate of mercury moistened upon copper is speedily decomposed by the superior affinity of the copper over mercury, for oxygen and fulminic acid. Dryness is, therefore, essential to the preservation of the fulminate; and hence charcoal, which is apt to become moist, should not be introduced into percussion caps destined for distant service.

2. An alcoholic solution of sandarach, commonly called spirit varnish, acts powerfully on copper, with the production of a green efflorescence, which decomposes ful-

minate of mercury. Indeed, sandarach can decompose the salts of copper. It is therefore ill adapted for attaching the fulminate to copper caps.

3. An alcoholic solution of shellac acts on copper, though more feebly than the sandarach.

4. A solution of mastic in spirits of turpentine, whether alone or mixed with fulminate, has no action whatever on bright copper, but protects it from being tarnished. Such a varnish is very cheap, dries readily, adheres strongly, screens the fulminate from damp, and does not impair or counteract its detonating powers. This, therefore, is, in my opinion, the fittest medium for attaching the fulminate, and for softening the force of its impulsion in any degree preportional to the thickness of the varnish."

Fulminate of mercury is obtained in white grains, or short needles, of a silky lustre, which become gray upon exposure to light, and detonate either by a blow or at a heat under 370° F.; with the disengagement of azote, carbonic acid, as also of aqueous and mercurial vapors; to the sudden formation of which gaseous products the report is due. It detonates even in a moist condition; and when dry it explodes readily when struck between two pieces of iron, less so between iron and bronze, with more difficulty between marble and glass, or between two surfaces of marble or glass. It is hardly possible to explode it by a blow with iron upon lead; and impossible by striking it with iron upon wood. It fulminates easily when rubbed between two wooden surfaces; less so between two of marble, two of iron, or one of iron against one of wood or marble. The larger its crystals, the more apt they are to explode. By damping it with 5 per cent. of water, it becomes less fulminating; the part of it struck still explodes with a proper blow, but will not kindle the adjoining portion. Though moistened with 30 per cent. of water, it will occasionally explode by trituration between a wooden muller and a marble slab, but only to a small extent, and never with any danger to the operator. When an ounce of it, laid upon the bottom of a cask, is kindled, it strikes a round hole down through it, as if it had been exposed to a four-pound shot, without splintering the wood. If a train of fulminate of mercury be spread upon a piece of paper, covered with some loose gunpowder, in exploding the former the latter will not be kindled, but merely scattered. When gunpowder, however, is packed in a cartridge, or otherwise, it may be certainly kindled by a percussion cap of the fulminate, and more completely than by a priming of gunpowder. 8¼ parts of gunpowder exploded by a percussion cap, have an equal projectile force as 10 exploded by a flint lock. If we add to this economy in the charge of the barrel, the saving of the powder for priming, the advantage in military service of the percussion system will become conspicuous.

The French calculate that 1 kilogramme of mercury will furnish 1¼ kil. (2½ lbs. nearly) of fulminate, which will be sufficient to charge 40,000 percussion caps. For this purpose they grind the crystalline salt along with 30 per cent. of water upon a marble table with a wooden muller; mixing with every 10 parts of the fulminate 6 of gunpowder. A consistent dough is thus obtained, which, being dried in the air, is ready for introducing into the bottoms of the copper caps. One quarter of a grain of the fulminate is said to be fully sufficient for one priming.

Mr. Lovell, of the Royal Manufactory of Arms, has lately executed a series of experiments upon priming powders. His trials, which occupied nearly 18 months, were made for the purpose of ascertaining what is the advantage in point of *force* obtained by using percussion primes. He had anticipated some extra energy would be imparted to the charge of powder in the barrel, because he had repeatedly proved that a good strong cap, exploded by itself on the nipple of the musket (without any charge of gunpowder), will exert sufficient force upon the air within the barrel to blow a candle out at a distance of 12 feet from the muzzle. He concluded also that stopping the escape of fluid from the vent, as is done by the cap, would have some effect, but he attributed most to the quickness and energy with which the powder of the charge is ignited by the vivid stream of flame, generated by the percussion prime. The trials were made from one and the same barrel, having a percussion lock on one side and a flint lock on the other. The balls were fired against Austen's recoiling target, a very delicate *plegometer*, beginning with a charge of 150 grains (the present musket charge), and descending by 10 grains at a time (firing 30 rounds with each weight), down to 50 grains. The machine marked the decrease of force at each reduction in the charge very satisfactorily, and the result of the whole average was, that 8·84 parts of gunpowder fired by percussion are equal to 10 parts fired by the flint.

To find out what sort of liberties might be taken with fulminate of mercury in handling it, he placed 3 grains on an anvil, putting the end of a steel punch gently on the top of it, and while so placed he covered the fulminate over with a drachm of dry gunpowder. He then ignited the fulminate by a blow on the punch with the hammer, but not a grain of the gunpowder was lighted, though it was blown about in all directions. He then placed a train of fulminate as thick as a quill, and about 3 feet long, on a table, and covered it over entirely with gunpowder except about an inch at one

end; this he lighted with a hot iron, when the whole train went off without blazing a grain of the gunpowder, which he swept together and blew up afterwards with a match.   He then took a tin box containing 500 copper caps, made a hole in the top of the box, and through this hole ignited one of the caps in the middle, by means of the punch and hammer on the outside; only two other caps besides the one struck exploded; no injury was sustained by the remainder, except being discolored.   This he tried repeatedly, and always with the same kind of result, never more than 3 or 4 caps exploding. He then made a steel rammer red hot, and passed it through the hole in the box right in amongst the caps, but it only ignited them where the hot iron came in actual contact with the priming composition; when, however, he placed a few grains of gunpowder loose among the caps, the hot iron lighted this, and produced a flame that blew off the whole of them.

The same thing has been tried at Woolwich, where large packages of percussion caps (some thousands) have been fired at with musket balls, and only a few of the caps actually hit by the ball exploded; but when any cartridges were connected with the packages, the whole, caps and all, were blown up.   The flame of the fulminate is therefore hazardous, but being so very ethereal, it requires for making primes, an admixture of some combustible matter, as a little gunpowder, to condense or modify the flame.

FULMINIC ACID (*Acid fulminique*, Fr.; *Knallsäure*, Germ.) is the explosive constituent of the fulminating mercury of Howard, and the fulminating silver of Brugnatelli, being generated by the reaction of alcohol and the acid nitrates of these metals.   It is a remarkable chemical fact, that fulminic acid has exactly the same composition as cyanic acid; though the salts of the latter possess no detonating property, and afford, in their decomposition by an oxygen acid, ammonia with carbonic acid; while those of the former afford ammonia and prussic acid.   All attempts to insulate fulminic acid have proved unsuccessful, as it explodes with the slightest decomposing force.   It consists, by weight, of 2 primes of carbon, 1 of azote, and 1 of oxygen; or of two volumes of carbonic acid, and one of azote.   When two different bodies, like the above, have the same composition, they are said to be *isomeric*.

FUMIGATION, is the employment of fumes or vapors to purify articles of apparel, and goods or apartments supposed to be imbued with some infectious or contagious poison or fumes.   The vapors of vinegar, the fumes of burning sulphur, explosion of gunpowder, have been long prescribed and practised, but they have in all probability little or no efficacy.   The diffusion of such powerful agents as chlorine gas, muriatic acid gas, or nitric acid vapor, should alone be trusted to for the destruction of morbific effluvia.

FUR ; See PELTRY.

FURNACE OF ASSAY.   Under Assay, I have referred to a furnace constructed by Messrs. Anfrye and d'Arcet, which gives some peculiar facilities and economy to the ancient process by fire. It had originally a small pair of bellows attached to it, for raising the heat rapidly to the proper vitrifying pitch.   The furnace, $17\frac{1}{2}$ inches high, and $7\frac{1}{2}$ inches wide, made of pottery or fine clay, is represented *fig.* 481, supported upon a table, having a pair of bellows beneath it.   The laboratory is at b, the blow-pipe of the bellows at d, with a stop-cock, and the dome is surmounted by a chimney $a\ c$, in whose lower part there is an opening with a sliding door, for the introduction of the charcoal fuel.   The furnace is formed in three pieces; a dome, a body, and an ash-pit. A pair of tongs, a stoking hook, and cupel, are seen to the right hand, and the plan of the stone-ware grate, pierced with conical holes, and a poker, are seen to the left. This grate suits the furnace represented under Assay.   The following are comparative experiments made by means of this furnace.
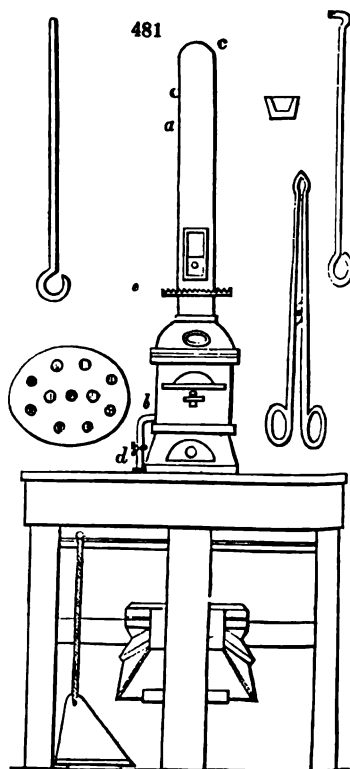
Numbers.	Silver employed.	Lead employed.	Time of assay.	Standards.	Charcoal used.
1	1 Grain.	4 Grains.	12 minutes.	947 millièmes.	173 Grains.
2	—	—	11	950	86
3	—	—	13	949	93
4	—	—	10	949	60

Each assay was therefore performed at an average in 11½ minutes, and not much more than a quarter of a pound of charcoal was used. An experiment of verification in the ordinary assay furnace showed the standard to be 949 thousandths.

This furnace becomes a very convenient one for melting small quantities of metals in analyses, by removing the muffle, and closing the several apertures with their appropriate stoppers. A small pedestal may be then set in the middle of the grate, to support a crucible, which may be introduced through the opening *h*. Coke may also be used as fuel, either by itself or mixed with charcoal. For descriptions of various furnaces, see ASSAY; BEER; COPPER; EVAPORATION; IRON; METALLURGY; ORES; SILVER, TIN, &c.

FUSIBILITY. That property by which solids assume the fluid state.

Some chemists have asserted that fusion is simply a solution in caloric; but this opinion includes too many yet undecided questions, to be hastily adopted.

Fusibility of Metals, as given by M. Thenard.

Centigr.

1. **Fusible below a red heat.**

Mercury	—39°
Potassium	+58° } Gay Lussac and Thenard.
Sodium	90 }
Tin	210 } Newton.
Bismuth	256 }
Lead	260 Biot.
Tellurium	A little less fusible than lead.—Klaproth.
Arsenic	Undetermined.
Zinc	370° Brongniart.
Antimony	A little below a read heat.
Cadmium	Stromeyer.

Pyrometer of Wedgewood.

2. **Infusible below a red heat.**

Silver	20 Kennedy.
Copper	27 } Wedgewood.
Gold	32 }
Cobalt	A little less difficult to melt than iron.
Iron	{ 130 Wedgewood. { 158 Sir G. M'Kenzie.
Manganese	160 Guyton.
Nickel	As manganese.—Richter.
Palladium	
Molybdenum	
Uranium	Nearly infusible; and to be obtained at a
Tungsten	forge heat only in small buttons.
Chromium	
Titanium	
Cerium	
Osmium	Infusible at the forge furnace. Fusible at
Iridium	the oxyhydrogen blowpipe. See BLOW-
Rhodium	PIPE.
Platinum	
Columbium	

FUSIBLE METAL. See ALLOY.

FUSTET. (*Fustec*, Fr.) The wood of the *rhus cotinus*, a fugitive yellow dye.

FUSTIAN is a species of coarse thick tweeled cotton, and is generally dyed of an olive, leaden, or other dark color. Besides the common fustian, which is known by the name of pillow (probably pilaw), the cotton stuffs called corduroy, velverett, velveteen, thicksett, used for men's wearing apparel, belong to the same fabric. The commonest kind is merely a tweel of four, or sometimes five leaves, of a very close stout texture, and very narrow, seldom exceeding 17 or 18 inches in breadth. It is cut from the loom in half pieces, or ends, as they are usually termed, about 35 yards long, and after undergoing the subsequent operations of dyeing, dressing, and folding, is ready for the market.

The draught and cording of common fustian is very simple, being generally a regular or unbroken tweel of four or five leaves. Below are specimens of a few different kinds, selected from those most general in Lancashire.

The number of leaves of heddles are represented by the lines across the paper, and the *cording* by the ciphers in the little squares, those which raise every leaf being distinguished by these marks, and those which sink them left blank, as more particularly explained in the article TEXTILE FABRIC.

Of velvet, there are properly only two kinds, that with a plain, and that with a tweeled, or, as it is here called, a Genoa ground, or back. When the material is silk, it is called velvet, when cotton, velveteen; and this is the sole difference. In the same way a common tweeled cloth, when composed of silk is called satin; when of cotton, fustian or jean; of woollen, plaiding, serge, or kerseymere; and in the linen trade is distinguished by a variety of names according to the quality or fineness, or the place where the article is manufactured.

No. 1.—Pillow Fustian.   No. 2.—Plain Velveret.

0				4		5		1	6		0					3	1
	0			3	6			6	0					6		
		0	6	2		3		6	0		0	0		0	2
			0	5	1	4		6				0		6	4
2	4	3	1						4	6	2	3	1
											5			

Of the above, each contains four leaves of heddles or healds; that represented by No. 1 is wrought with four treddles, and that which is distinguished by No. 2 by five; the succession of inserting the threads of warp into the heddles will be discovered by the figures between the lines, and the order in which the treddles are to be successively pressed down by the figures below.

No. 3.—Double Jean.   No. 4.—Plain Thickset.

0			0		1	6		0				8	
0		0		2		6		0	0	0		6	4
	0	0		3		6					0		5	2
	0		0	4		6		0		0	0	7	3	1
4	2	3	1				4	6	2	3	1	
									5		7	

These, like the former, are wrought with leaves. No. 3 requires four, and No. 4 five treddles. The succession of inserting the threads of warp, and of working the treddles, are marked by the respective numbers between and under the lines, as in the former example. Both are fabrics of cloth in very general use and estimation as low priced articles.

No. 5.—Best Thickset.   No. 6.—Velvet Tuft.

0			0	0		3	1	6		0				5	3	1
				0		5		6		0	0				4	2
	0				2		6	0		0	0	4	2		
	0	0		6	4		6			0			5	3	1
6	4	2	3	1			6	4	2	3	1	
		5										

These are further specimens of what may be, and is, executed with four leaves, and in both examples five treddles are used. With two other specimens we shall conclude our examples of this description of work, and shall then add a very few specimens of the more extensive kinds.

No. 7.—Cord and Velveret.   No. 8.—Thickset Cord.

	0				3	1		3	1	6	0			0	0		5	3	1
	0	0			5		7	5		6		0					4	2
0			0	0	6	8		2	6						9	7	
			0		4	2	6	4	6		0	0		10	8	6
4		2	3	1					5	4	3	2	1	
	6	5										

In these the succession of drawing and working are marked like the former. The next are examples of patterns wrought with six leaves. No. 9 has eight, and No. 10 five heddles.

No. 9.—Double Corduroy.   No. 10.—Genoa Thickset.

In both these the warp is inserted into the heddles the same way. The difference is entirely in the application of the cords, and in the succession of pressing down the treddles. We now give four specimens of the flushed and cut work, known by the name of velveteen. They are also upon six leaves, and the difference is solely in the cording and in the treading.

No. 11.   Queen's Velveteens.   No. 12.

No. 13.—Plain Velveteen.   No. 14.—Genoa Velveteen.

The additional varieties of figure which might be given are almost endless, but the limits of this article will not admit a further detail. Those already given are the articles in most general use. The varieties of fancy may be indulged to a great extent; but it is universally found, that the most simple patterns in every department of ornamental weaving are those which attract attention and command purchasers. We shall therefore only add two examples of king's cord or corduroy, two of Genoa and common velvet, and two more of jean. These will be found below.

No. 15.—King's Cord.   No. 16.—Dutch Cord.

No. 17.—Genoa Velvet.   No. 18.—Plain Velvet.

After the fustian cloth is taken from the loom-beam, it is carried to the cutter, who rips up the surface-threads of weft, and produces thereby a hairy-looking stuff.

Preparatory to its being cut, the cloth is spread evenly upon a table about six feet long, upon each end of which a roller mounted with a ratchet-wheel is fixed; the one to give off, and the other to wind up the piece, in the above six-feet lengths.

The knife is a steel rod about two feet long, and three eighths of an inch square, having a square handle at the one end; the other end is tapered away to a blade, as thin as paper. To prevent this point from turning downwards and injuring the cloth, its under side is covered by a guide which serves to stiffen it, as well as to prevent its lower edge from cutting the fustian.

The operative (male or female) grasps the handle in the right hand, and insinuating the projecting point of the guide under the weft, pushes the knife smartly forward through the whole length of six feet, with a certain dexterous movement of the shoulder and right side, balancing the body meanwhile, like a fencer, upon the left foot. This process is repeated upon every adhesive line of the weft.

The next process to which fustians are exposed is steeping in hot water, to take out the dressing paste. They are then dried, reeled, and brushed by a machine, &c. From twenty to thirty pieces, each eighty yards long, may be brushed in an hour. The breadth of the cloth is twenty inches. The maceration is performed by immersing the bundled pieces in tanks of water, heated by waste steam; and the washing by means of a reel or winch, kept revolving rapidly under the action of a stream of cold water, for an hour or longer.

After being thus ripped up, it is taken to the brushing or teazling machine, to make it shaggy.

This consists of a series of wooden rollers, turning freely upon iron axles, and covered with tin-plate, rough with the burs of punched holes; and blocks of wood, whose concave under surfaces are covered with card-cloth or card-brushes, and which are made to traverse backwards and forwards in the direction of the axes of the revolving rollers, during the passage of the cloth over them.

After they are brushed in the machine, the goods are singed by passing their cut surface over a cylinder of iron, laid in a horizontal direction, and kept red hot by a flue. See SINGEING. They are now brushed again by the machine, and once more passed over the singeing surface. The brushing and singeing are repeated a third, or even occasionally a fourth time, till the cord acquires a smooth polished appearance.

The goods are next steeped, washed, and bleached, by immersion in solution of chloride of lime. They are then dyed by appropriate chemical means. After which they are padded (imbued by the padding machine of the calico printers) with a solution of glue, and passed over steam cylinders to stiffen them.

Smooth fustians, when cropped or shorn before dyeing, are called moleskins; but when shorn after being dyed, are called beaverteen: they are both tweeled fabrics. Cantoon is a fustian with a fine cord visible upon the one side, and a satiny surface of yarns running at right angles to the cords upon the other side. The satiny side is sometimes smoothed by singeing. The stuff is strong, and has a very fine aspect. Its price is one shilling and sixpence a yard.

Common plain fustian, of a brown or drab color, with satin top, is sold as low as sevenpence a yard.

A fustian, with a small cord running in an oblique direction, has a very agreeable appearance. It is called diagonal. Moleskin shorn, of a very strong texture, and a drab dyed tint, is sold at 20d. per yard.

The weight of 90 yards of the narrow velveteen, in the green or undressed state, is about 24 pounds. The goods made for the German, Italian, and Russian markets are lighter, on account of the peculiarity in the mode of levying the import duty in these countries.

Velveteens as they come from the loom, are sold wholesale by weight, and average a price of 20d. per pound. They are usually woven with yarns of Upland and Brazil cotton wool, spun together for the warp; or, sometimes, New Orleans alone. The weft is usually Upland, sometimes mixed with East India cotton wools.

Trouser velveteens are woven 19 inches wide, if they are to be cut up; if not, they are woven 30 inches, and called beaverteen.

Cutting or cropping fustians by hand is a very laborious and delicate operation. The invention of an improved apparatus for effecting the same end with automatic precision and despatch, was therefore an object of no little interest to this peculiar manufacture of Manchester. An ingenious machine, apparently well calculated for this purpose, was made the subject of a patent by Messrs. William Wells and George Scholefield, of Salford, in November, 1834.

FUSTIC. (*Bois jaune*, Fr.; *Gelbholz*, Germ.) The *old* fustic of the English dyer, as the article fustet is their *yellow* fustic. It is the wood of the Morus tinctoria. It is light, not hard, and pale yellow with orange veins; it contains two coloring matters, one resinous, and another soluble in water. The latter resembles weld, but it has more of an orange cast, and is not so lively.

Its decoctions in water are brightened by the addition of a little glue, and more by cur-
dled milk. This wood is rich in color, and imparts permanent dyes to woollen stuffs,
when aided by proper mordants. It unites well with the blue of the indigo vat, and
Saxon blue, in producing green of various shades. Alum, tartar, and solution of tin,
render its color more vivid; sea salt and sulphate of iron deepen its hue. From 5 to 6
parts of old fustic are sufficient to give a lemon color to 16 parts of cloth. The color of
weld is however purer and less inclining to orange; but that of fustic is less affected by
acids than any other yellow dye. This wood is often employed with sulphate of iron in
producing olive and brownish tints, which agree well with its dull yellow. For the same
reason it is much used for dark greens.

G.

GABRONITE is a yellowish stony substance, of a greasy lustre and spec. gr.=2·74;
affording no water by calcination; fusible at the blowpipe into an opaque glass; soluble
in muriatic acid; solution affords hardly any precipitate by oxalate of ammonia. This
mineral is distinguished by the large quantity of soda which it contains; its constituents
being—silica, 54; alumina, 24; soda, 17·25; magnesia, 1·5; oxyde of iron, 1·25; water,
2. It belongs to the species Nepheline.

GADOLINITE, called also Yttrite and Ytterbite, is a mineral of a black, brownish,
or yellowish color, granular, or compactly vitreous, and conchoidal fracture; of spec.
grav. 4·23; readily scratching glass; fusible at the blowpipe into an opaque glass, some-
times with intumescence. It affords, with acids, a solution that lets fall, with caustic
soda, a precipitate partly re-soluble in carbonate of ammonia. It is remarkable for con-
taining from 45 to 55 per cent. of the earth Yttria; its remaining constituents being sili-
ca, 25·8; oxyde of cerium, 17·92; oxyde of iron, 11·43. This mineral is very rare, hav-
ing been hitherto found only in the neighborhood of Fahlon and Ytterby, in Sweden; its
peculiar constituent was discovered by Professor Gadolin. .

GALACTOM TER, or LACTOMETER, is an instrument to ascertain the quality
of milk; an article often sophisticated in various ways. Fresh milk, rich in cream, has a
less specific gravity than the same milk after it has been skimmed; and milk diluted with
water becomes proportionably lighter. Hence, when our purpose is to determine the
quantity of cream, the galactometer may consist merely of a long graduated glass tube
standing upright upon a sole. Having filled 100 measures with the recent milk, we shall
see, by the measures of cream thrown up, its value in this respect. A delicate long-
ranged glass hydrometer, graduated from 1·000 up to 1·060, affords the most convenient
means of detecting the degree of watery dilution, provided the absence of thickening ma-
terials has been previously ascertained by filtration. Good fresh milk indicates from 1·030
to 1·032; when the cream is removed, 1·035 to 1·037. When its density is less than 1·028,
we may infer it has been thinned with water.

GALBANUM is a gum-resin, which occurs sometimes in yellow, shining tears, easily
agglutinated; of a strong durable smell; an acrid and bitter taste; at other times in lumps.
It exudes either spontaneously or from incisions made into the stem of the *bubon galbanum*,
a plant of the family of *umbelliferæ*, which grows in Africa, particularly in Ethiopia. It
contains 67 of resin; 19·3 of gum; 6·4 of volatile oil and water; 7·5 of woody fibres and
other impurities; with traces of acid malate of lime.

GALENA, (*Plomb sulfuré*, Fr.; *Bleiglanz*, Germ.;) is a metallic looking substance of
a lead-gray color, which crystallizes in the cubical system, and is susceptible of cleavages
parallel to the faces of the cube; spec. gr. 7·7592; cannot be cut; fusible at the blow-
pipe with exhalation of sulphureous vapors; is easily reduced to metallic lead. Nitric
acid first dissolves it, and then throws down sulphate of lead in a white precipitate; the
solution affording, with plates of zinc, brilliant laminæ of lead (arbor Saturni.) It con-
sists of sulphur, 13; lead, 85; with a little iron, and sometimes a minute quantity of silver.
This is the richest ore of lead, and it occurs in almost every geological formation, in
veins, in masses, or in beds. It is almost always accompanied by sulphuret of zinc, dif-
ferent salts of lead, heavy spar, fluor spar, &c. Galena in powder, called Alquifoux, is
employed as a glaze for coarse stoneware.

GALIPOT is a name of a white semi-solid viscid rosin found on fir-trees; or an infe-
rior sort of turpentine, poor in oil.

GALLATES; salts consisting of gallic acid combined with bases; the most important
being that with oxyde of iron, constituting a principal part of the black dye.

GALLIC ACID is the peculiar acid extracted from gall-nuts; which see.

GALLIPOLI OIL is a coarse olive oil, containing more or less mucilage; imported from
a seaport so named, of the province of Otranto, in the kingdom of Naples.

GALL-NUTS, or GALLS, (*Noix de Galle*, Fr.; *Galläpfel*, Germ.;) are excrescences
found upon the leaves and leaf-stalks of a species of oak, called *Quercus infecto-
ria*, which grows in the Levant. They are produced in consequence of the puncture
of the female of the gall wasp (Cynips folii quercus), made in order to deposite her

eggs; round which the juice of the tree exudes, and dries in concentric portions. When the insect gets fully formed, it eats through the nut, and flies off.

The Levant galls are of two different appearances and qualities; the first are heavy, compact, imperforated, the insect not having been sufficiently advanced to eat its way through the shell; prickly on the surface; of a blackish or bluish green hue; about the size of a musket-ball. These are called *black*, blue, or Aleppo galls. The second are light, spongy, pierced with one or more holes; smooth upon the surface, of a pale grayish or reddish yellow color, generally larger than the first, and are called *white* galls. Besides the galls of the Levant, others come from Dalmatia, Illyria, Calabria, &c.; but they are of inferior quality, being found upon the *Quercus Cerris*; they are smaller, of a brownish color, and of inferior value. The further south the galls are grown, they are reckoned the better.

Galls consist principally of three substances; tannin or tannic acid; yellow extractive; and gallic acid. Their decoction has a very astringent and unpleasant bitter taste. The following are their habitudes with various reagents:—

Litmus paper is powerfully reddened.

Stannous chloride (*protomuriate of tin*) produces an isabel yellow precipitate.

Alum; a yellowish gray precipitate.

Acetate of lead; a thick yellowish white precipitate.

Acetate of copper; a chocolate brown precipitate.

Ferric sulphate (red sulphate of iron); a blue precipitate.

Sulphuric acid; a dirty yellowish precipitate.

Acetic acid brightens the muddy decoction.

The galls of the *Quercus Cerris* and common oak (*Galles à l'épine*, Fr.; *Knoppern*, Germ.) are of a dark brown color, prickly on the surface, and irregular in shape and size. They are used chiefly for tanning in Hungary, Dalmatia, and the southern provinces of the Austrian states, where they abound.

Tannin or tannic acid is prepared as follows: Into a long narrow glass adopter tube, shut at its lower orifice with a cotton wick, a quantity of pounded galls are put, and slightly pressed down. The tapering end of the tube being inserted into a matrass or bottle, the vacant upper half of the tube is filled with sulphuric ether, and then closed with a ground-glass stopper. Next day there will be found in the bottle a liquid in two distinct strata; of which the more limpid occupies the upper part, and the other, of a sirupy consistence and amber color, the lower. More ether must be filtered through the galls, till the thicker liquid ceases to augment. Both are now poured into a funnel, closed with the finger, and after the dense liquor is settled at the bottom, it is steadily run off into a capsule. This, after being washed repeatedly with ether, is to be transferred into a stove chamber, or placed under the receiver of an air pump, to be evaporated. The residuary matter swells up in a spongy crystalline form of considerable brilliancy, sometimes colorless, but more frequently of a faintly yellowish hue.

This is pure tannin, which exists in galls to the amount of from 40 to 45 per cent. It is indispensable that the ether employed in the preceding process be previously agitated with water, or that it contain some water, because by using anhydrous ether, not a particle of tannin will be obtained.

Tannic acid is a white or yellowish solid, inodorous, extremely astringent, very soluble in water and alcohol, much less so in sulphuric ether, and uncrystallizable. Its watery solution, out of contact of air, undergoes no change; but if, in a very dilute state, it be left exposed to the atmosphere, it loses gradually its transparency, and lets fall a slightly grayish crystalline matter, consisting almost entirely of gallic acid. For procuring this acid in a perfectly pure state, it is merely necessary to treat that solution thus changed with animal charcoal, and to filter it, in a boiling state, through paper previously washed with dilute muriatic acid. The gallic acid will fall down in crystals as the liquid cools.

If the preceding experiment be made in a graduated glass tube containing oxygen over mercury, this gas will be absorbed, and a corresponding volume of carbonic acid gas will be disengaged. In this case the liquor will appear in the course of a few weeks as if traversed with numerous crystalline colorless needles of gallic acid.

Tannin or tannic acid consists of carbon 51·56; hydrogen 4·20; oxygen 44·24.

From the above facts it is obvious that gallic acid does not exist ready formed in gall-nuts, but that it is produced by the reaction of atmospheric oxygen upon the tannin of these concretions.

Gallic acid is a solid, feebly acidulous and styptic to the taste, inodorous, crystallizing in silky needles of the greatest whiteness; soluble in about 100 times its weight of cold, and in a much smaller quantity of boiling water; more soluble in alcohol than in water, but little so in sulphuric ether.

Gallic acid does not decompose the salts of protoxyde of iron, but it forms, with the sulphate of the peroxyde, a dark blue precipitate, much less insoluble than the tannate of iron. Gallic acid takes the oxyde from the acetate and nitrate of lead, and throws

down a white gallate unchangeable in the air, when it is mixed with that acetate and nitrate. It occasions no precipitate in solutions of gelatine (isinglass or glue), by which criterion its freedom from tannin is verified.

Gallic acid occurs but seldom in nature; and always united to brucine, veratrine, or lime. Its constituents are carbon 49·89; hydrogen 3·49; oxygen 46·62. In the crystalline state it contains one atom of water, which it loses by drying.

Scheele obtained gallic acid by infusing pounded galls for 3 or 4 days in 8 times their weight of water, and exposing the infusion to the air, in a vessel covered loosely with paper. At the end of two months, the liquor had almost all evaporated, leaving some mouldiness mixed with a crystalline precipitate. The former being removed, the deposite was squeezed in a linen cloth, and then treated with boiling water. The solution, being gradually evaporated, yielded crystals of gallic acid, granular or star-like, of a grayish color. These crystals might be whitened by boiling their solution along with a little animal charcoal. About one fifth of gallic acid may be obtained by Scheele's process from good gall-nuts.

From a decoction of 500 parts of galls, Sir H. Davy obtained 185 parts of solid extract; which consisted of 130 parts of tannin; 31 parts of gallic acid with extractive; 13 parts of mucilage; 12 parts of lime and salts. Hence gall-nuts would seem to contain, by this statement, more than two thirds of their weight of tannin. This result is now seen, from the above experiments of Pelouze, to have been incorrect, in consequence of the admixture of yellow extractive in Davy's tannin.

The use of galls in many processes of dyeing, and in making black ink, is detailed under their respective heads.

GALL OF ANIMALS, or OX-GALL, *purification of.* Painters in water colors, scourers of clothes, and many others, employ ox-gall or bile; but when it is not purified, it is apt to do harm from the greenness of its own tint. It becomes therefore an important object to clarify it, and to make it limpid and transparent like water. The following process has been given for that purpose. Take the gall of newly killed oxen, and after having allowed it to settle for 12 or 15 hours in a basin, pour the supernatant liquor off the sediment into an evaporating dish of stone ware, and expose it to a boiling heat in a water bath, till it is somewhat thick. Then spread it upon a dish, and place it before a fire till it becomes nearly dry. In this state it may be kept for years in jelly pots covered with paper, without undergoing any alteration. When it is to be used, a piece of it of the size of a pea is to be dissolved in a table spoonful of water.

Another and probably a better mode of purifying ox-gall is the following. To a pint of the gall boiled and skimmed, add one ounce of fine alum in powder, and leave the mixture on the fire till the alum be dissolved. When cooled, pour into a bottle, which is to be loosely corked. Now take a like quantity of gall, also boiled and skimmed, add an ounce of common salt to it, and dissolve with heat; put it when cold into a bottle, which is likewise to be loosely corked. Either of these preparations may be kept for several years without their emitting a bad smell. After remaining three months, at a moderate temperature, they deposite a thick sediment, and become clearer, and fit for ordinary uses, but not for artists in water colors and miniatures, on account of their yellowish-green color. To obviate this inconvenience, each of the above liquors is to be decanted apart, after they have become perfectly settled, and the clear portion of both mixed together in equal parts. The yellow coloring matter still retained by the mixture coagulates immediately and precipitates, leaving the ox-gall perfectly purified and colorless. If wished to be still finer, it may be passed through filtering paper; but it becomes clearer with age, and never acquires a disagreeable smell, nor loses any of its good qualities.

Clarified ox-gall combines readily with coloring matters or pigments, and gives them solidity either by being mixed with or passed over them upon paper. It increases the brilliancy and the durability of ultramarine, carmine, green, and in general of all delicate colors, whilst it contributes to make them spread more evenly upon the paper, ivory, &c. When mixed with gum-arabic, it thickens the colors without communicating to them a disagreeable glistering appearance; it prevents the gum from cracking, and fixes the colors so well that others may be applied over them without degradation. Along with lamp black and gum, it forms a good imitation of China ink. When a coat of ox-gall is put upon drawings made with black lead or crayons, the lines can no longer be effaced, but may be painted over safely with a variety of colors previously mixed up with the same ox-gall.

Miniature painters find a great advantage in employing it; by passing it over ivory, it removes completely the unctuous matter from its surface; and when ground with the colors, it makes them spread with the greatest ease, and renders them fast.

It serves also for transparencies. It is first passed over the varnished or oiled paper, and is allowed to dry. The colors mixed with the gall are then applied, and cannot afterwards be removed by any means.

It is adapted finally for taking out spots of grease and oil.

GALL OF GLASS, called also sandiver, is the neutral salt skimmed off the surface of melted crown glass; which, if allowed to remain too long, is apt to be re-absorbed in part, and to injure the quality of the *metal*, as the workmen call it.

GALVANIZED IRON is the somewhat fantastic name newly given in France to iron tinned by a peculiar patent process, whereby it resists the rusting influence of damp air, and even moisture, much longer than ordinary tin plate. The following is the prescribed process. Clean the surface of the iron perfectly by the joint action of dilute acid and friction, plunge it into a bath of melted zinc, and stir it about till it be alloyed super- ficially with this metal; then take it out, and immerse it in a bath of tin, such as is used for making tin plate. The tin forms an exterior coat of alloy. When the metal thus prepared is exposed to humidity, the zinc is said to oxydize slowly by a galvanic action, and to protect the iron from rusting within it, whereby the outer tinned surface remains for a long period perfectly white, in circumstances under which iron tinned in the usual way would have been superficially browned and corroded with rust.

GAMBOGE (*Gomme Gutte*, Fr.; *Gutti*, Germ.) is a gum resin, concreted in the air, from the milky juice which exudes from several trees. The *gambogia gutta*, a tree which grows wild upon the coasts of Ceylon and Malabar, produces the coarsest kind of gamboge; the *guttaefera vera* (*Stalagmites cambogioides*) of Ceylon and Siam affords the best. It comes to us in cylindrical lumps, which are outwardly brown yellow, but reddish yellow within, as also in cakes; it is opaque, easily reducible to powder, of specific gravity 1·207, scentless, and nearly devoid of taste, but leaves an acrid feeling in the throat. Its powder and watery emulsion are yellow. It consists of 80 parts of a hya- cinth red resin, soluble in alcohol; and 20 parts of gum; but by another analysis, of 80 of resin, and 10·5 of gum. Gamboge is used as a pigment, and in miniature painting, to tinge gold varnish; in medicine as a powerful purge. It should never be employed by confectioners to color their *liquors*, as they sometimes do.

GANGUE. A word derived from the German *gang*, a vein or channel. It signifies the mineral substance which either encloses or usually accompanies any metallic ore in the vein. Quartz, lamellar carbonate of lime, sulphate of baryta, sulphate and fluate of lime, generally form the gangues; but a great many other substances become such when they predominate in a vein. In metallurgic works the first thing is to break the mixed ore into small pieces, in order to separate the valuable from the useless parts, by pro- cesses called stamping, picking, sorting. See METALLURGY and MINES.

GARNET (*Grenat*, Fr.; *Granat*, Germ.) is a vitreous mineral of the cubic system, of which the predominating forms are the rhomboidal dodecahedron and the traperzohedron; specific gravity varying from 3·35 to 4·24; fusible at the blowpipe. Its constituents are, silica, 42; alumina, 20·0; lime, 34·0; protoxyde of iron, 4. Garnets are usually dis- seminated, and occur in all the primitive strata from gneiss to clay slate. The finer va- rieties, noble garnet or Almandine, and the reddish varieties of Grossulaire (Essonite), are employed in jewellery; the first are called the Syrian or oriental; the others, hyacinth, In some parts of Germany, garnets are so abundant as to be used as fluxes to some iron ores; in others, the garnet gravel is washed, pounded, and employed as a substitute for emery. The garnets of Pegu are most highly valued. Factitious garnets may be made by the following composition :—Purest white glass, 2 ounces; glass of antimony, 1 ounce; powder of cassius, 1 grain, manganese, 1 grain.

GAS (Eng. and Fr.; *Gaz*, Germ.) is the generic name of all those elastic fluids which are permanent under a considerable pressure, and at the temperature of zero of Fahren- heit. In many of them, however, by the joint influence of excessive cold and pressure, the repulsive state of the particles may be balanced or subverted, so as to transform the elastic gas into a liquid or a solid. For this most interesting discovery, we are indebted to the fine genius of Mr. Faraday.

The following table exhibits the temperatures and pressures at which certain gases are liquefied.

Name of the gas.	Becomes liquid		Calculated boiling point; Barom. = 30 inches.
	At	Under a pressure of	
Sulphurous acid　-　-	59° F.	3 atmospheres.	— 4° Fahr.
Chlorine　.　-　-	60	4	— 22
Ammonia　-　-　-	50	6·5	— 64
Sulphureted hydrogen　-　-	50	17	— 142
Carbonic acid　-　-　-	32	36	— 229
Hydrochloric or muriatic acid　-	50	50	— 249
Deutoxyde of azote　-　-	45	50	— 254

Liquid carbonic acid becomes solidified, into a snowy-looking substance, by its own rapid evaporation: Oxygen, hydrogen, and azote, have hitherto resisted all attempts to divest them of their elastic form. For this purpose, it is probable that a condensing force equal to that of 650 atmospheres, will be required.

The volume of any gas is, generally speaking, inversely as the pressure to which it is exposed; thus, under a double pressure its bulk becomes one half; under a triple pressure, one third; and so on. For the change of volume in gaseous bodies by heat, see EXPANSION.

Ammonia, carbonic acid, carbureted hydrogen, chlorine, muriatic acid, sulphurous acid, sulphureted hydrogen, are the gases of most direct interest in the arts and manufactures. Their detailed examination belongs to a work on chemistry.

GAS-LIGHT. (*Eclairage par gas*, Fr.; *Gaslicht*, Germ.) Dr. Clayton demonstrated, by numerous experiments in 1737 and 1738, that bituminous pit-coal subjected to a red heat in close vessels, afforded a great deal of an air similar to the fire-damp of mines, but which burned with a brighter flame. It does not appear that this species of factitious air was ever produced from pit-coal for the purpose of artificial illumination till 1792, when Mr. William Murdoch, engineer to Messrs. Bolton and Watt, employed coal gas for lighting his house and offices, at Redruth in Cornwall. The gas was generated in an iron retort, whence it was received in a gasometer, distributed in different situations by pipes, and finally burned at small apertures which could be opened and stopped at pleasure. He moreover made this light moveable, by confining the gas in portable tin-plate vessels, and burning it wherever he pleased. Between this period and 1802, Mr. Murdoch continued at intervals to make similar experiments; and upon occasion of the national illumination in the spring of the latter year, at the peace of Amiens, he lighted up part of the Soho manufactory with a public display of gas-lights.

The earliest application of this artificial light, on a large systematic scale, was made at Manchester; where an apparatus for lighting the great cotton mills of Messrs. Philips and Lee, was fitted up in 1804 and 1805, under the direction of Mr. Murdoch. A quantity of light, nearly equal to 3000 candles, was produced and distributed in this building. This splendid pattern has been since followed very generally in Great Britain, and more or less in many parts of the continents of Europe and America. By the year 1822, gas-lighting in London had become the business of many public companies. At the Peter street station, for example; 300 retorts had been erected, supplying 15 gasometers, having each an average capacity of 20·626 cubic feet, but, being never quite filled, their total contents in gas might be estimated at 309,385 cubic feet. The extent of main pipes of distribution belonging to this station was then about 57 miles, with two separate mains in some of the streets. The product of gas was from 10,000 to 12,000 cubic feet from a chaldron of coals. The annual consumption of coals was therefore altogether 9282 chaldrons, affording 11,384,000 cubic feet of gas, allowing 153 retorts to be in constant daily action, upon an average of the year; and illuminating 10,660 private lamps, 2248 street lamps, and 3894 theatre lamps.

At the Brick-lane works, 371 retorts were fixed in 1822, 133 being worked on an average of summer and winter. There were 12 gasometers, charged with an average quantity of gas amounting to 197,214 cubic feet. Of coals, 8060 chaldrons were annually consumed; 96,720,000 cubic feet of gas were generated; for the supply of 1978 public lamps, and 7366 private ones, connected with main pipes 40 miles long.

At the Curtain road gas establishment, there were 240 retorts; but the greatest number worked in 1821 was only 80, and the lowest 21. The six gasometers had an average contents of 90,467 cubic feet. Of coals, 3336 chaldrons were annually consumed, yielding 40,040,000 cubic feet of gas, that supplied 3860 private lamps, and 629 public ones, by means of mains 25 miles long. The above three stations belonged to the London Gas-Light and Coke Company.

The City of London Gas-Light Company, Dorset street, had built up 230 retorts, and 6 gasometers, while two were preparing; having a total capacity of 181,282 cubic feet. Of private lamps 5423 were lighted, and 2413 public ones, from mains extending 50 miles. The quantity of coals carbonized amounted to 8840 chaldrons; producing 106,080,000 cubic feet of gas.

The South London Gas-Light and Coke Company had mounted at Bankside 143 retorts, with 3 gasometers; the contents of the whole being 41,110 cubic feet, connected with mains from 30 to 40 miles long. At their other station, in Wellington street, 9 large gasometers were then erecting, with a capacity of 73,565 cubic feet, which were to be supplied with gas from Bankside, till retorts were mounted for them.

The Imperial Gas-Light and Coke Company had at that time 6 gasometers in progress at their Hackney station.

In 1822 there were thus four great companies, having in all 47 gasometers at work, capable of containing 917,940 cubic feet of gas, supplied by 1315 retorts, which generated

per annum upwards of 397,000,000 cubic feet of gas, by which 61,203 private lamps, and 7268 public or street lamps, were lighted in the metropolis. Besides these public companies, there were likewise several private ones.

1. *Of the generation of illuminating gases.*—Pure hydrogen gas burns with too feeble a flame to be employed for illumination. But carbureted hydrogen having the property of·precipitating its carbon in the act of burning, its solid particles become incandescent, and diffuse a vivid light. The more carbon it contains, the more brightly does it burn. This gas exists in two distinct states of combination. In the first, two measures of hydrogen gas are combined with one measure of the vapor of carbon, forming together one measure whose specific gravity is of course the sum of the weights of the constituents, or 0·559; atmospherical air being 1·000. This is the gas which is found in mines, and is also evolved in ditches from decomposing vegetable matter. In the second, two measures of hydrogen gas are combined with two of gaseous carbon, forming also one volume or measure whose weight or specific gravity is 0·985. This was at one time called the olefiant gas, because when mixed with chlorine an oily looking compound was produced. It may be called as well oil gas, because it is generated in considerable quantities by the igneous decomposition of oil. Thus the olefiant gas contains in the same volume double the quantity of carbon of common carbureted hydrogen, and it burns with a proportionably brighter flame. The gaseous oxyde of carbon, as well as sulphureted hydrogen gas, burns with a feeble blue light, but the latter produces in combustion sulphurous acid, an offensive and noxious gas.

By dry distillation or carbonization in close vessels, all bodies of vegetable and animal origin disengage carbureted hydrogen gas; even charcoal, when placed in ignition in contact with water, by decomposing the water, produces abundance of carbonic acid, carbureted hydrogen, hydrogen, and carbonic oxyde. After separating the carbonic acid with lime water, that mixed gas contains in 100 measures, 20 of carbureted hydrogen; the rest being hydrogen and carbonic oxyde, so that the gaseous mixture cannot be used for illumination. The best substances for furnishing a gas rich in luminiferous materials are, pitcoal, especially the cannel coal, resin, oil, fats of all kinds, tar, wax, &c. In some cases the gases evolved during the igneous decomposition of bones and other animal matters for the production of ammonia, may be employed for procuring light, but they are apt to emit a fetid odor.

When coals are heated in a cast-iron retort to ignition, the progress of decomposition is as follows. First, and before the retort becomes red hot, steam issues along with the atmospheric air. When the retort begins to redden, tar distils in considerable quantity with some combustible gas, of which hydrogen mixed with ammoniacal gas forms a part. The evolution of gas increases as the retort becomes hotter, with a continual production of tar and ammoniacal liquor as well as sulphurous acid from the pyrites of the coal, which unites with the ammonia. When the retort has come to a bright cherry red heat, the disengagement of gas is most active. By and by the gaseous production diminishes, and eventually ceases entirely, although the heat be increased. In the retort a quantity of carbonized coal or coke remains, while tar is found at the bottom of the receiver, covered with the ammoniacal liquor, and combined with carbonic and sulphurous acids, and sulphureted hydrogen.

If, during this distillation, the combustible gas be collected and examined at the several stages of the process, it is found to differ extremely in its luminiferous powers. That which comes off before the retort has acquired its proper temperature, gives a feeble light, and resembles the gas obtained by the ignition of moist charcoal, consisting chiefly of hydrogen. That evolved when the retort has just acquired throughout a vivid red heat, is the best of all, consisting chiefly of bi-carbureted hydrogen or olefiant gas. From good coal, it consists, for example, in 100 measures, of 13 of olefiant gas, 82·5 of carbureted hydrogen, 3·2 carbonic oxyde, 1·3 azote; the mixture having a specific gravity of 0·650. At a later period, as after 5 hours, it contains 7 measures of olefiant gas, 56 of carbureted hydrogen, 11 of carbonic oxyde, 21·3 of hydrogen, 4·7 of azote; the specific gravity of the whole being 0·500. Towards the end of the operation, as after 10 hours, it contains twenty measures of carbureted hydrogen, 10 of carbonic oxyde, 60 of hydrogen, 10 of azote, with a specific gravity of only 0·345. The hydrogen becomes sulphureted hydrogen, if there be much pyritous matter in the coal. The larger proportion of the gas is disengaged during the first hour, amounting to about one fifth of the whole; in the three following hours the disengagement is tolerably uniform, constituting in all fifty-four hundredths; in the sixth hour, it is one tenth; in the seventh and eighth hours, sixteen hundredths.

From these observations are derived the rules for the production of a good light gas from coals. They show that the distillation should commence with a retort previously heated to a cherry red, since thereby good gas is immediately produced, and a portion of the tar is also converted into gas, instead of being simply distilled over into the condenser pit; that this heat should be steadily continued during the whole operation, from 5 to 8 hours; that it should not be increased, especially towards the end, for fear

erating carbonic oxyde and hydrogen gases, as well as of injuring the retort when
oling agency of gasefication has become feeble; and that the operation should be
d some time before gas ceases to come over, lest gases with feeble illuminating power
l impoverish the contents of the gasometer. Upon the average, a pound of good coal
s four cubic feet of gas, or a chaldron=26 cwts. London measure, affords from 12,000
000 cubic feet, according to the form of the retort, and the manner of firing it.
en oil, fats, rosin, tar, &c. are employed for the production of a light gas, it is not
ent to introduce these substances into the retorts, and to heat them, as is done
coals. In this case, the greater part of them would distil over in the state of vola-
ls, and very little gas be generated, only as much as corresponded to the quantity
, &c. in immediate contact with the retort. It becomes therefore necessary to
e retorts with pieces of brick or coke; and to keep them in ignition, while the
e. is slowly introduced into their interior. The fats instantly assume the vaporous
and thus coming into contact upon an extensive surface with the ignited bricks,
ecomposed into combustible gases. A small portion of carbonaceous matter re-
in the retort, while much olefiant gas is formed, possessing a superior illumi-
ɡ power to common coal gas, and entirely free from sulphureous impregnation.
est oil gas is generated at a dull red, a heat much below what is requisite for the
iposition of coal. A more intense heat would indeed produce a greater volume
s, but of a poorer quality, because the olefiant gas thereby deposites one half of
rbon, and is converted into common carbureted hydrogen. Oil affords at a lively
eat, gases which contain in 100 measures, 19 of olefiant gas, 32·4 of carbureted
gen, 12·2 of carbonic oxyde gas, 32·4 of hydrogen, and 4 of azote; the mean specific
y being only 0·590. At a more moderate temperature it yields 22·5 of the
ɪt, 50·3 carbureted hydrogen, 15·5 carbonic oxyde, 7·7 hydrogen, and 4 azote,
a specific gravity of 0·758. It contains when generated by dull ignition, as is
in works on the manufacturing scale, in 100 parts from 38 to 40 of olefiant gas,
esides the carbureted hydrogen, a few per cent. of carbonic oxyde and azote,
a specific gravity of 0·900, and even upwards. One pound of oil or fluid fat affords
bic feet of gas; of tar affords about 12 cubic feet; of rosin or pitch, 10 cubic feet.
en the oil gas is compressed by a force of from 15 to 20 atmospheres, as was the
ce of the Portable Gas Company, about one fifth of the volume of the gas becomes
ied into an oily, very volatile fluid, having the specific gravity 0·821. It is a
re of three fluids (consisting of carbureted hydrogen), of different degrees of
lity. The most volatile of these boils even under 32° F. Some of the vapor of
as-oil is mixed with the olefiant gas in the general products of decomposition; in
quence of which they are sometimes richer in carbon than even olefiant gas, and
a higher illuminating power. Oil gas contains about 22 per cent. and coal gas
3¼ per cent. of this oily vapor. In the estimations of the composition of the
given above, this vapor is included under olefiant gas. This vapor combines
ɪ with sulphuric acid, and is thus precipitated from the gaseous mixture. The
nt of olefiant gas is shown, by adding to the gas, contained over water, one half of
lume of chlorine, which, in the course of an hour or two, condenses the olefiant gas
ɪn oily looking liquid (chloride of hydrocarbon.) After the mixture, the gases
be screened from the light, otherwise the common carbureted hydrogen would also
ne with the chlorine, while water and carbonic acid would make their appearance.
: oil employed for affording gas is the crudest and cheapest that can be bought; even
ubber and sediment of whale oil are employed with advantage. After all, however,
s so much cheaper, and the gas produced from it is now so well purified, that oil
osin are very little used in gas apparatus.

aratus for Coal Gas.—Coal gas, as it issues from the retort, cannot be directly
yed for illumination; for it contains vapors of tar and coal oil, as also steam
gnated with the carbonate, sulphite, and hydrosulphuret of ammonia. These
s would readily condense in the pipes through which the gas must be dis-
ed, and would produce obstructions; they must therefore be so far removed by
as cooling, as to be liable to occasion no troublesome condensation at ordinary
ratures. The crude coal gas contains moreover sulphureted hydrogen, whose com-
n for light would exhale an offensive sulphureous odor, that ought to be got
as much as possible. Carbonic acid and carbonic oxyde gases, generated at first
he decomposition of the steam by the ignited coal, enfeeble the illuminating power
: gas, and should be removed. The disengagement of gas in the retorts is never
m, but varies with the degree of heat to which they are exposed; for which
ɪ the gas must be received in a gasometer, where it may experience uniform pres-
and be discharged uniformly into the pipes of distribution, in order to ensure a
discharge of gas, and uniform intensity of light in the burners. A coal gas appa-
ought therefore to be so constructed as not only to generate the gas itself, but to fulfil
ove conditions.

In *fig.* 482, such an apparatus is represented, where the various parts are shown connected with each other, in section.

A is the furnace with its set of cylindrical or elliptical retorts, five in number. From each of these retorts, a tube *b* proceeds perpendicularly upwards, and then by a curve or saddle-tube, it turns downwards, where it enters a long horizontal cylinder under B, shut at each end with a screw cap, and descends to beneath its middle, so as to dip about an inch into the water contained in it. From one end of this cylinder the tube *d* passes downward, to connect itself with a horizontal tube which enters into the *tar pit* or *cistern* c, by means of the vertical branch *f*. This branch reaches to near the bottom of the cylindrical vessel, which sits on the sole of the tar cistern. From the other side of the vertical branch *f*, the main pipe proceeds to the condenser D, and thence by the pipe *l*, into the purifier E; from which the gas is immediately transmitted by the pipe *p* into the gasometer F.
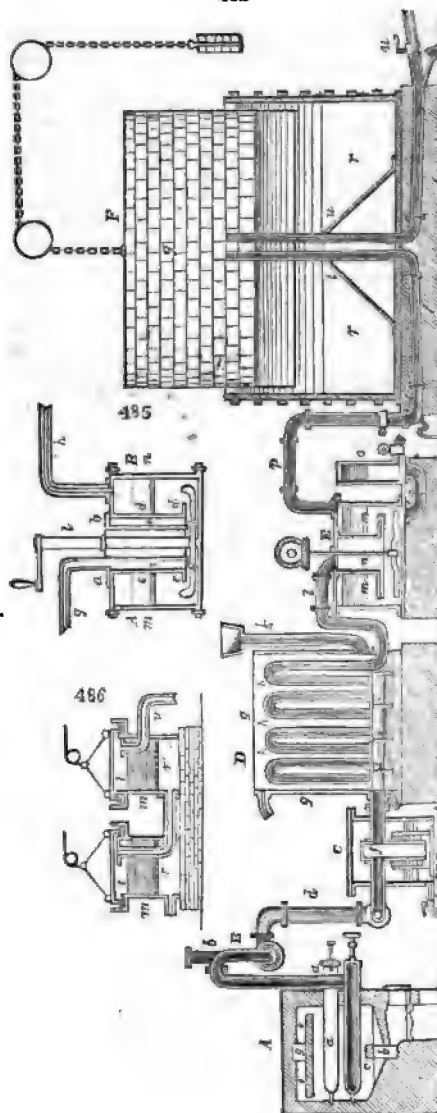
The operation proceeds in the following way :—As soon as gas begins to be disengaged from the ignited retort, tar and ammoniacal liquor are deposited in the cylindrical receiver B, and fill it up till the superfluity runs over by the pipe *d*, the level being constantly preserved at the line shown in the figure. By the same tarry liquid, the orifices of the several pipes *b*, issuing from the retorts, are closed ; whereby the gas in the pipe *d* has its communication cut off with the gas in the retorts. Hence if one of the retorts be opened and emptied, it remains shut off from the rest of the apparatus. This insulation of the several retorts is the function of the pipe under B, and therefore the recurved tube *b* must be dipped as far under the surface of the tarry liquid, as to be in equilibrio with the pressure of the gas upon the water in the purifier. The tube *b* is closed at top with a screw cap, which can be taken off at pleasure, to permit the interior to be cleansed.

Both by the overflow from the receiver-pipe B, and by subsequent condensation in the tube *d*, tar and ammoniacal liquor collect progressively in the cistern or pit under c, by which mingled liquids the lower orifice of the vertical tube *f* is closed, so that the gas cannot escape into the empty space of this cistern. These liquids flow over the edges of the inner vessel when it is full, and may from time to time be drawn off by the stopcock at the bottom of the cistern.

Though the gas has, in its progress hitherto, deposited a good deal of its tarry and ammoniacal vapors, yet, in consequence of its high temperature, it still retains a considerable portion of them, which must be immediately abstracted, otherwise the tar

would pollute the lime in the vessel x, and interfere with its purification. On this account the gas should, at this period of the process, be cooled as much as possible, in order to condense these vapors, and to favor the action of the lime in the purifier x, upon the sulphureted hydrogen, which is more energetic the lower the temperature of the gas. The coal gas passes, therefore, from the tube f into the tube h of the condenser D, which is placed in an iron chest g filled with water, and it deposites more tar and ammoniacal liquor in the under part of the cistern at t, t. When these liquids have risen to a certain level, they overflow into the tar-pit, as shown in the figure, to be drawn off by the stop-cock as occasion may require.

The refrigerated gas is now conducted into the purifier E, which is filled with milk of lime, made by mixing one part of slaked lime with 25 parts of water. The gas, as it enters by the pipe l, depresses the water in the wide cylinder n, thence passes under the perforated disc in the under part of that cylinder, and rising up through innumerable small holes is distributed throughout the lime liquid in the vessel m. By contact with the lime on this extended surface, the gas is stripped of its sulphureted hydrogen and carbonic acid, which are condensed into the hydro-sulphuret and carbonate of lime; it now enters the gasometer F in a purified state, through the pipe p t, and occupies the space q. The gasometer, pressing with a small unbalanced force over the counterweight s, expels it through the main u u, in communication with the pipes of distribution through the buildings or streets to be illuminated.

The parts A B C D E and F, of which this apparatus consists, are essential constituents of every good coal-gas work. Their construction rests upon peculiar principles, is susceptible of certain modifications, and therefore deserves to be considered in detail.

The Retorts. — These are generally made of cast iron, though they have occasionally been made of baked clay, like common earthenware retorts. The original form was a cylinder, which was changed to an ellipse, with the long axis in a horizontal direction, then into the shape of the letter D with the straight line undermost, and lastly into a semi-cylinder, with its horizontal diameter 22 inches, and its vertical varying from 9 to 12. The kidney form was at one time preferred, but it has been little used of late.

The form of retort represented in *fig.* 483 has been found to yield the largest quantity
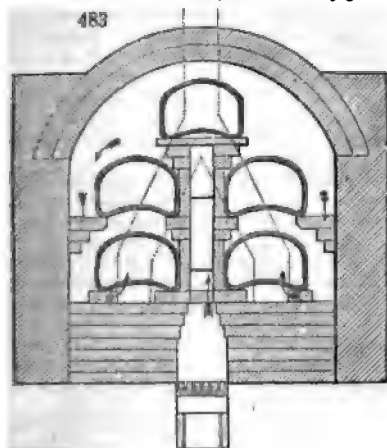
of good gas in the shortest time, and with the least quantity of firing. The length is 7½, and the transverse area, from one foot to a foot and a half square. The arrows show the direction of the flame and draught in this excellent bench of retorts, as mounted by Messrs. Barlow.

The charge of coals is most conveniently introduced in a tray of sheet iron, made somewhat like a grocer's scoop, adapted to the size of the retort, which is pushed home to its further end, inverted so as to turn out the contents, and then immediately withdrawn.

The duration of the process, or the time of completing a distillation, depends upon the nature of the coal and the form of the retort. With cylindrical retorts it cannot be finished in less than 6 hours, but with elliptical and semi-cylindrical retorts, it may be completed in 4 or 5 hours. If the distillation be continued in the former for 8

hours, and in the latter for 6, gas will continue to be obtained, but during the latter period of the operation, of indifferent quality.

The Receiver. — If the furnace contains only 2 or 3 retorts, a simple cylindrical vessel standing on the ground half filled with water, may serve as a receiver; into which the tube from the retort may be plunged. It should be provided with an overflow pipe for the tar and ammoniacal liquor. For a range of several retorts, a long horizontal cylinder is preferable, like that represented at B in *fig.* 484. Its diameter is from 10 to 15 inches. This cylinder may be so constructed as to separate the tar from the ammoniacal liquor, by means of a syphon attached to one of its ends.

The Condenser. — The condenser, represented in *fig.* 482, consists of a square chest g, made of wrought iron plates open at top, but having its bottom pierced with a row of holes, to receive a series of tubes. To these holes the upright four-inch tubes h h are secured by flanges and screws, and they are connected in pairs at top by the curved or saddle tubes. The said bottom forms the cover of the chest t, t, which is divided by vertical iron partitions, into half as many compartments as there are tubes.

These partition plates are left open at bottom, so as to place the liquids of each compartment in communication. Thereby the gas passes up and down the series of tubes, in proceeding from one compartment to another. The condensed liquids descend into the box t, t, and flow over into the tar cistern, when they rise above the level t, t. The tar may be drawn off from time to time by the stopcock. Through the tube k, cold water flows into the condenser chest, and the warm water passes away by a pipe at its upper edge.

The extent of surface which the gas requires for its refrigeration before it is admitted into the washing-lime apparatus, depends upon the temperature of the milk of lime, and the quantity of gas generated in a certain time.

It may be assumed as a determination sufficiently exact, that 10 square feet of surface of the condenser can cool a cubic foot of gas per minute to the temperature of the cooling water. For example, suppose a furnace or arch with 5 retorts of 150 pounds of coal each, to produce in 5 hours 3000 cubic feet of gas, or 10 cubic feet per minute, there would be required, for the cooling surface of the condenser, 100 square feet $= 10 \times 10$. Suppose 100,000 cubic feet of gas to be produced in 24 hours, for which 8 or 9 such arches must be employed, the condensing surface must contain from 800 to 900 square feet.

The Purifier. — The apparatus represented in the preceding figure is composed of a cylindrical iron vessel, with an air-tight cover screwed upon it, through which the cylinder a is also fixed air-tight. The bottom of this cylinder spreads out like the brim of a hat, forming a horizontal circular partition, which is pierced with holes. Through a stuffing box, in the cover of this interior cylinder, the vertical axis of the agitator passes, which is turned by wheel and pinion work, in order to stir up the lime from the bottom of the water in the purifier. The vessel o serves for introducing fresh milk of lime, as also for letting it off by a stopcock when it has become too foul for further use.

The quantity of lime should be proportioned to the quantity of sulphureted hydrogen and carbonic acid contained in the gas. Supposing that in good coal gas there is 5 per cent. of these gases, about one pound and a half of lime will be requisite for every hundred cubic feet of coal gas generated, which amounts to nearly one sixteenth of the weight of coal subjected to decomposition. This quantity of lime mixed with the proper quantity of water will form about a cubic foot of milk of lime. Consequently, the capacity of the purifier, that is, of the interior space filled with liquid, may be taken at four sevenths of a cubic foot for every hundred cubic feet of gas passing through it in one operation; or for 175 cubic feet of gas, one cubic foot of liquor. After every operation, that is, after every five or six hours, the purifier must be filled afresh. Suppose that in the course of one operation 20,000 cubic feet of gas pass through the machine, this should be able to contain $\frac{20,000}{175} = 114$ cubic feet of milk of lime; whence its diameter should be seven feet, and the height of the liquid three feet. If the capacity of the vessel be less, the lime milk must be more frequently changed.

In some of the large gas works of London the purifier has the following construction, whereby an uninterrupted influx and efflux of milk of lime takes place. Three single purifiers are so connected together, that the second vessel stands higher than the first, and the third than the second; so that the discharge tube of the superior vessel, placed somewhat below its cover, enters into the upper part of the next lower vessel; consequently, should the milk of lime in the third and uppermost vessel rise above its ordinary level, it will flow over into the second, and thence in the same way into the first; from which it is let off by the eduction pipe. A tube introduces the gas from the condenser into the first vessel, another tube does the same thing for the second vessel, &c., and the tube of the third vessel conducts the gas into the gasometer. Into the third vessel, milk of lime is constantly made to flow from a cistern upon a higher level. By this arrangement, the gas passing through the several vessels in proportion as it is purified, comes progressively into contact with purer milk of lime, whereby its purification becomes more complete. The agitator c, provided with two stirring paddles, is

ontinual rotation. The pressure which the gas has here to overcome is naturally
es as great as with a single purifier of like depth.

$5 is a simple form of purifier, which has been found to answer well in practice.
the cover of the vessel A B, the wide cylinder e d is inserted, having its lower
ed with numerous holes. Concentric with that cylinder is the narrower one s z,
ove with the flange a b, but open at top and bottom. The under edge g h of
der descends a few inches below the end c d of the outer one. About the middle
ssel the perforated shelf m n is placed. The shaft of the agitator l, passes
a stuffing box upon the top of the vessel. The gas-pipe g, proceeding from the
r, enters through the flange a b in the outer cylinder, while the gas-pipe h goes
cover to the gasometer. A stopcock upon the side, whose orifice of discharge is
t higher than the under edge of the outer cylinder, serves to draw off the milk

As the gas enters through the pipe g into the space between the two cylinders,
es the liquor till it arrives at the holes in the under edge of the outer cylinder,
which, as well as under the edge, it flows, and then passes up through the aper-
the shelf m n into the milk of lime chamber; the level of which is shown by
d line. The stirrer, l, should be turned by wheel work, though it is here shown
motion by a winch handle.

r to judge of the degree of purity of the gas after its transmission through the
hine, a slender syphon tube provided with a stopcock may have the one end
in its cover, and the other dipped into a vessel containing a solution of acetate
Whenever the solution has been rendered turbid by the precipitation of sulphu-
d, it should be renewed. The saturated and fetid milk of lime is evaporated
g cast-iron troughs placed in the ash-pit of the furnaces, and the dried lime
employed for luting the apparatus, and partly disposed of for a mortar or

purifier, and others of similar construction, the gas in the preceding parts of
atus, as in the retorts and the condenser, suffers a pressure equal to a column
about two feet high; and in the last described purifier even a greater pressure.
ssure is not disadvantageous, but is of use in two respects; 1. it shows by a
of gas when the apparatus is not air-tight, and it prevents common air from
into the retorts; 2. this compression of the gas favors the condensation of the
mmoniacal liquor. The effect of such a degree of pressure in expanding the
the ignited retorts is quite inconsiderable, and may be neglected. Two contri-
ave, however, been proposed for taking off this pressure in the purifier.

486, m m are two similar vessels of a round or rectangular form, furnished at
per border with a groove filled with water, into which the under edge of the
, so as to make the vessel air-tight. The cover is suspended by a cord or chain,
es over a pulley, and may be raised or lowered at pleasure. The vessels them-
ve perforated bottoms, r r', covered with wetted moss or hay sprinkled over with
d sifted quicklime. The gas passes through the loosely compacted matter of
vessel, by entering between its two bottoms, rises into the upper space t, thence
ds to the second vessel, and, lastly, through the pipe u, into the gasometer.

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This method, however, requires
twice as much lime as the former,
without increasing the purity of
the gas.

The second method consists in
compressing the gas by the ac-
tion of an Archimedes screw, to
such a degree, before it is admit-
ted into the purifier, as that it
may overcome the pressure of
the column of water in that
vessel. Fig. 487 exhibits this
apparatus in section. D D is the
Archimedes worm, the axis of
which revolves at bottom upon
the gudgeon e; it possesses a
three-fold spiral, and is turned
in the opposite direction to that
in which it scoops the water.
The cistern which contains it has
an air-tight cover. The gas to
be purified passes through the
pipe c into the space D, over the
vel d; the upper cells of the worm scoop in the gas at this point, and
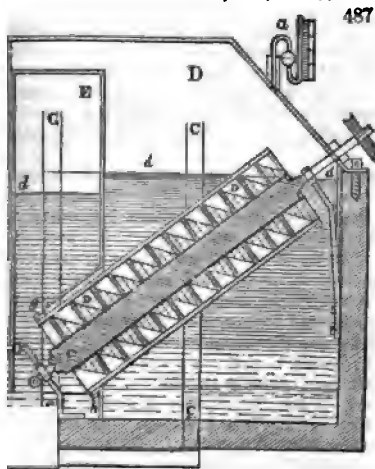
carry it downwards, where it enters at g into the cavity x of a second cistern. In order that the gas, after it escapes from the bottom of the worm, may not partially return through g into the cavity D, an annular plate $g\,h$ is attached to its under edge, so as to turn over it. The compressed gas is conducted from the cavity x through the pipe 6 into the purifying machine; a is a manometer, to indicate the elastic tension of the gas in D. On the top of the worm a mechanism is fitted for keeping it in constant rotation.

A perfect purification of light-gas from sulphureted hydrogen, either by milk of lime or a solution of the green sulphate of iron, is attended with some difficulty, when carried so far as to cause no precipitation of sulphuret in acetate of lead, because such a degree of washing is required as is apt to diminish its illuminating power, by abstracting the vapor of the rich oily hydrocarburet which it contains. Moreover, the coal gas obtained towards the end of the distillation contains some sulphuret of carbon, which affords sul-phurous acid on being burned, and can be removed by no easy method hitherto known. The lime in the purifier disengages from the carbonate and hydro-sulphuret of ammonia carried over with the gas, especially when it has been imperfectly cooled in the condenser, a portion of ammoniacal gas, which, however, is not injurious to its illuminating power. The best agent for purifying gas would be the pyrolignite of lead, were it not rather ex-pensive, because it would save the trouble of stirring, and require a smaller and simpler apparatus.

The Gasometer.—The gasometer serves not merely as a magazine for receiving the gas when it is purified, and keeping it in store for use, but also for communicating to the gas in the act of burning such a uniform pressure as may secure a steady unflick-ering flame. It consists of two essential parts; 1. of an under cistern, open at top and filled with water; and 2. of the upper floating cylinder or chest, which is a similar cistern inverted, and of somewhat smaller dimensions, called the gas-holder; see r, *fig.* 482. The best form of this vessel is the round or cylindrical; both because under equal capacity it requires least surface of metal, and it is least liable to be warped by its own weight or accidents. Since a cylindrical body has the greatest capacity with a given surface when its height is equal to its semi-diameter, its dimensions ought to be such that when elevated to the highest point in the water, the height may be equal to the radius of the base. For example, let the capacity of the gas-holder in cubic feet be k, the semi-diameter of its base be x, the height out of the water be h;

h is $= x = \sqrt[3]{\dfrac{k}{3\cdot 14}}$. This height may be increased by one or two feet, according to its

magnitude, to prevent the chance of any gas escaping beneath its under edge, when it is raised to its highest elevation in the water.

The size of the gasometer should be proportional to the quantity of gas to be con-sumed in a certain time. If 120,000 cubic feet be required, for instance, in 10 hours for street illumination, and if the gas retorts be charged four times in 24 hours, 30,000 feet of gas will be generated in 6 hours. Hence the gasometer should have a capacity of at least 70,000 cubic feet, supposing the remaining 50,000 cubic feet to be produced during the period of consumption. If the gasometer has a smaller capacity, it must be supplied from a greater number of retorts during the lighting period, which is not advantageous, as the first heating of the supernumerary retorts is wasteful of fuel. Some engineers consider that a capacity of 30,000 cubic feet is the largest which can with propriety be given to a gasometer; in which case they make its diameter 42 feet, and its height 23. When the dimensions are greater, the sheet iron must be thicker and more expensive; and the hollow cylinder must be fortified by strong internal cross braces.

The water cistern is usually constructed in this country with cast-iron plates bolted to-gether, and made tight with rust-cement.

In cases where the weight of water required to fill such a cistern might be inconvenient to sustain, it may be made in the form represented in *fig.* 488; which, however, will cost nearly twice as much. Parallel with the side of the cistern, a second cylinder c, of the same shape, but somewhat smaller, is fixed in an inverted position to the bottom of the first, so as to leave an annular space $B\ B$ between them, which is filled with water, and in which the floating gasometer A plays up and down. The water must stand above the cover of the inverted cylinder. a and b are the pipes for leading the gas in and out. Through an opening in the masonry upon which the gasometer apparatus rests, the space c may be entered, in order to make any requisite repairs.

The water cistern may also be sunk in the ground, and the sides made tight with hydraulic mortar, as is shown in *fig.* 488, and to make it answer with less water, a con-centric cylindrical mass of masonry may be built at a distance of 2 or 3 inches within it.

Every large gasometer must be strengthened interiorly with cross iron rods, to stiffen both its top and bottom. The top is supported by rods stretching obliquely down to

the sides, and to the under edge an iron ring is attached, consisting of curved cast iron bars bolted together; with which the oblique rods are connected by perpendicular ones.
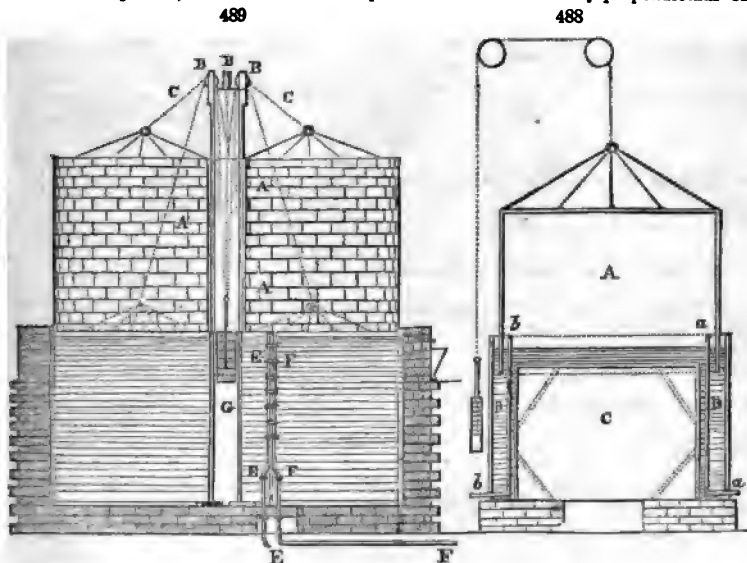
Other vertical rods stretch directly from the top to the bottom edge. Upon the periphery of the top, at the end of the rods, several rings are made fast, to which the gas-holder is suspended, by means of a common chain which runs over a pulley at the centre. Upon the other end of the chain there is a counterpoise, which takes off the greater part of the weight of the gas-holder, leaving only so much as is requisite for the expulsion of the gas. The inner and outer surfaces of the gas-holder should be a few times rubbed over with hot tar, at a few days' interval between each application. The pulley must be made fast to a strong frame.

If the water cistern be formed with masonry, the suspension of the gas-holder may be made in the following way. A A, *fig.* 489, is a hollow cylinder of cast iron, standing up through the middle of the gasometer, and which is provided at either end with another small hollow cylinder G, open at both ends and passing through the top, with its axis placed in the axis of the gas-holder. In the hollow cylinder G, the counterweight moves up and down, with its chain passing over the three pulleys B, B, B, as shown in *fig.* 489. E F are the gas pipes made fast to a vertical iron rod. Should the gasometer be made to work without a counterweight, as we shall presently see, the central cylinder A A, serves as a vertical guide.

In proportion as the gas-holder sinks in the water of the cistern, it loses so much of its weight, as is equal to the weight of the water displaced by the sides of the sinking vessel; so that the gas-holder when entirely immersed, exercises the least pressure upon the gas, and when entirely out of the water, it exercises the greatest pressure. In order to counteract this inequality of pressure, which would occasion an unequal velocity in the efflux of the gas, and of course an unequal intensity of light in its flame, the weight of the chain upon which the gas-holder hangs is so adjusted as to be equal, throughout the length of its motion, to one half of the weight which the gas holder loses by immersion. In this case, the weight which it loses by sinking into the water, is replaced by the portion of the chain which, passing the pulley, and hanging over, balances so much of the chain upon the side of the counterweight; and the weight which it gains by rising out of the water, is counterpoised by the links of the chain which, passing over the pulley, add to the amount of the counterweight. The pressure which the gas-holder exercises upon the gas, or that with which it forces it through the first main pipe, is usually so regulated as to sustain a column of from one to two inches of water; so that the water will stand in the cistern from one to two inches higher within, than without the gas-holder. The following computation will place these particulars in a clear light.

Let the semi-diameter of the gas-holder, equal to the vertical extent of its motion into and out of the water, = x; let the weight of a foot square of the side of the gas-holder, including that of the strengthening bars and ring, which remain plunged under the water, be = p; then

1. the weight of the gas-holder in its highest position $= 3\,p\,\pi\,x^2$;
2. the weight of the sides of the gas-holder which play in the water $= 2\,p\,\pi\,x^2$;
3. the cubic contents of the immersed portion of the gas-holder $= \dfrac{2\,p\,\pi\,x^2}{400}$;
4. its loss of weight in water $= \dfrac{112}{400}\,p\,\pi\,x^2$;
5. the weight of the gas-holder in its lowest position $=$

$$p\,\pi\,x^2\left(3 - \frac{112}{400}\right) = 2\cdot72\,p\,\pi\,x^2;$$

6. the weight of n inches, height of water $= \dfrac{56}{12}\,n\,\pi\,x^2$;

7. the amount of the counterweight $= \pi\,x^2)\,3\,p - \dfrac{56\,n}{12}\Big)$;

8. the weight of the chain for the length $x = \dfrac{112}{800}\,p\,\pi\,x$.

If we reduce the weight of the gas-holder in its highest and lowest positions to the height of a stratum of water equal to the surface of its top, this height is that of the column of water which would press the gas within the gasometer, were no counterweight employed; it consists as follows :—

9. for the highest position $= \dfrac{3\,p}{56}$;

10. for the lowest $= \dfrac{2\cdot72\,p}{50}$;

For the case, when the height of the gas-holder is different from its semi-diameter, let this height $= m\,x$; then the height of the water level is—

11. for the highest position $= p\left(\dfrac{1+2\,m}{56}\right)$;

12. for the lowest $= p\left(\dfrac{1+1\cdot72m}{6}\right)$;

13. the counterweight $= \pi\,x^2\left(p\,(1+2m) - \dfrac{56n}{12}\right)$;

14. the weight of the equalizing chain $= \dfrac{112}{800}\,p\,\pi\,m\,x^2$.

For example, let the diameter of the gas-holder be 30 feet, the height 15 (the contents in cubic feet will be 10,597), $p = 4$ pounds; then the counterweight for a height of an inch and a half of water pressure $= 3532$ pounds; the weight of the chain for a length of 15 feet $= 395$ pounds. Were no counterweight employed, so that the gas-holder pressed with its whole weight upon the gas, then the height of the equivalent column of water in its highest position $= 2\cdot56$ inches; and in its lowest, $2\cdot33$. The counterweight may hence be lessened at pleasure, if the height of the pressing water-column n be increased. The weight of the equalizing or compensating portion of the chain remains the same. When $n = 2$ inches, for instance, the counterweight $= 1886$ pounds.

The velocity with which the gas passes along the mains for supplying the various jets of light, may be further regulated by opening the main-cock or slide-valve in a greater or less degree. Gasometers whose height is greater than their semi-diameter, are not only more costly in the construction, but require heavier counterweights and equilibration chains.

The above estimate is made on the supposition of the gas in the gas-holder being of the same specific gravity as the atmospherical air, which would be nearly true with regard to oil gas under the ordinary pressure. But coal gas, whose specific gravity may be taken on an average at about 0·5, exercises a buoyancy upon the top of the gas-holder, which of course diminishes its absolute weight. Supposing the cubic foot of gas to be $= 0\cdot0364$ pounds, the buoyancy will be $= 0\cdot0364\,\pi\,x^3$ pounds; a quantity which deserves to be taken into account for large gasometers. Hence,

15. the weight of the gas-holder in its highest position $= 3\,p\,\pi\,x^2 - 0\cdot1143\,x^3$;

16. the counterweight $= \pi\,x^2\left(3\,p - \dfrac{56\,n}{12}\right) - 0\cdot1143\,x^2$;

17. the weight of the chain for the length $x = \dfrac{112}{800}\,p\,\pi\,x^2 - \dfrac{0\cdot1143\,x^3}{2}$;

18. The height of the water pressure for the highest position, without the counterweight $= \dfrac{3\,p\,\pi - 0\cdot1143\,x}{56\,\pi}$;

19. the same for the lowest position $= \dfrac{2\cdot72\,p}{56}$ in feet

ing values of p and x are,

7; (17) = 203; (18) = 2·44 inches; (19) = 2·33 inches.
columns in the highest and lowest situations of the gas-holder here differ
in inch, and this difference becomes still less when p has a smaller value,
pounds, or when the diameter of the gas-holder is still greater.
as appear that for coal-gas gasometers, in which the height of the gas-holder
d its semi-diameter, and especially when it has a considerable size, neither
a chain nor a counterweight is necessary. The only thing requisite, is to
vertical motion of the gas-holder by a sufficient number of guide rods or
either within the water cistern, or round about it. Should the pressure
he pipe proceeding from the gasometer, be less than in the gasometer itself,
egulated by the main valve, or by water valves of various kinds. Or a small
egulating gasometer may be introduced between the great gas-holder, and
of distribution. With a diameter of 61 feet in the gas-holder, the pressure
and lowest positions is the same.
eters employed in storing up gas until required for use, occupy, upon the
h space, and are attended with considerable expense in erecting. The
hether sunk in the ground or raised, must be of equal dimensions with
r, both in breadth and depth. The improved construction which we are
ibe, affords a means of reducing the depth of the tank, dispensing with the
ension, and of increasing at pleasure the capacity of the gasometer, upon a
thus rendering a small apparatus capable, if required, of holding a large
is, the first cost of which will be considerably less than even a small gas-
ucted upon the ordinary plan.
of Mile-End Road, the inventor, has, we believe, been for some years
h gas establishments, and is therefore fully aware of the practical defects
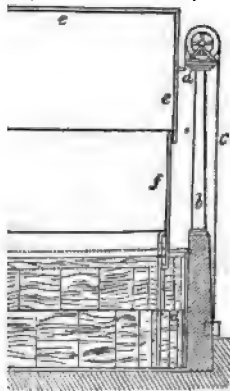
or advantages of the different constructions of
gasometers now in use. *Fig.* 490 is a section
of Mr. Tait's improved contrivance; *a a* is the
tank, occupied with water, *b b* two iron col-
umns, with pulley-wheels on the top, *c c*,
chains attached to a ring of iron, *d d*, extend-
ing round the gasometer, which chains pass
over the pulley-wheels, and are loaded at their
extremities, for the purpose of balancing the
weight of the materials of which the gasometer
is composed.

The gasometer is formed by 2 or 3 cylinders,
sliding one within the other, like the tubes
of a telescope; *e, e, e,* is the first or outer cyl-
inder, closed at the top, and having the ring
of iron *d*, passing round it, by which the whole
is suspended; *f f*, is the second cylinder, sliding
freely within the first, and there may be a third
and fourth within these if necessary.

is no gas in the apparatus, all the cylinders are slidden down, and remain
other immersed in the tank of water; but when the gas rises through the
against the top of the gasometer, its buoyancy causes the cylinder *e* to as-
the lower edge of this cylinder a groove is formed by the turning in of the
and as it rises, the edge takes hold of the top rim of the cylinder *f*, which is
that purpose. The groove at the bottom of the cylinder fills itself with
cends, and by the rim of the second cylinder falling into it, an air-tight hy-
produced.
al cylinders may be adapted to act in a small tank of water, by sliding one
ier, with lapped edges forming hydraulic joints, and by supporting the ap-
way shown, the centre of gravity will always be below the points of sus-
asometer may be made upon this plan of any diameter, as there will be no
-work, or a bridge to support it; and the increasing weight of the appara-
inders are raised one after the other, may be counterpoised by loading the
ains *c c.*
in the gasometer need not be renewed; but merely so much of it as
leaks out, is to be replaced. Indeed, the surface of the water in the cistern
with a stratum of coal oil, a few inches deep, which prevents its evaporation,
gas to be saturated with this volatile substance, so as to increase its illu-
rs.
eter may be separated from the purifier by an intermediate vessel, such
ited *fig.* 491, with which the two gas pipes are connected. A is the

cylindrical vessel of cast iron a, the end of the gas pipe which comes from the purifier, immersed a few inches deep into the liquid with which the vessel is about two thirds filled; b is the gas-pipe which leads into the gasometer; c is a perpendicular tube, placed over the bottom of the vessel, and reaching to within one third of the top, through which the liquid is introduced

491 into the vessel, and through which it escapes when it overflows the level d. In this tube the liquid stands towards the inner level higher, in proportion to the pressure of the gas in the gasometer. The fluid which is condensed in the gas-pipe b, and in its prolongation from the gasometer, runs off into the vessel A; and therefore the latter must be laid so low that the said tube may have the requisite declivity. A straight stopcock may also be attached to the side over the bottom, to draw off any sediment.
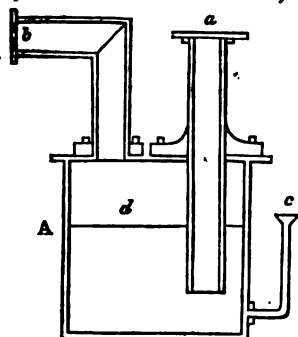
II. APPLICATION OF LIGHT-GAS.

1. *Distribution of the pipes.*—The pressure by which the motion of the gas is maintained in the pipes, corresponds to a certain height of water in the cistern of the gasometer. From the magnitude of this pressure, and the quantity of gas which in a given time, as an hour, must be transmitted through a certain length of pipes, depends the width or the diameter that they should have, in order that the motion may not be retarded by the friction which the gas, like all other fluids, experiences in tubes, and thereby the gas might be prevented from issuing with the velocity required for the jets of flame. The velocity of the gas in the main pipe increases in the ratio of the square root of the pressing column of water upon the gasometer, and therefore by increasing this pressure, the gas may be forced more rapidly along the remoter and smaller ramifications of the pipes. Thus it happens, however, that the gas will be discharged from the orifices near the gasometer, with superfluous velocity. It is therefore advisable to lay the pipes in such a manner, that in every point of their length the velocity of discharge may be nearly equal. This may be nearly effected as follows :—

From experiment it appears that the magnitude of the friction, or the resistance which the air suffers in moving along the pipes, under a like primary pressure, that is, for equal initial velocity, varies with the square root of the length. The volume of gas discharged from the end of a pipe is directly proportional to the square of its diameter, and inversely as the square root of its length ; or, calling the length L, the diameter D, the cubic feet of gas discharged in an hour k; then $k = \dfrac{D^2}{\sqrt{L}}$. Experience likewise shows, that for a pipe 250 feet long, which transmits in an hour 200 cubic feet of gas, one inch is a sufficient diameter.

Consequently, $200 : k :: \dfrac{1}{144 \sqrt{250}} : \dfrac{D^2}{\sqrt{L}}$; and $D = \dfrac{\sqrt{k} \ \sqrt{L}}{455,000}$

From this formula the following table of proportions is calculated.

Number of cubic feet per hour.	Length of pipe, in feet.	Diameter, in inches.
50	100	0·40
250	200	1·00
500	600	1·97
700	1000	2·65
1000	1000	3·16
1500	1000	3·87
2000	1000	4·47
2000	2000	5·32
2000	4000	6·33
2000	6000	7·00
6000	1000	7·75
6000	2000	9·21
8000	1000	8·95
8000	2000	16·65

These dimensions are applicable to the case where the body of gas is transmitted through

pipes without being let off in its way by burners, that is, to the mains which conduct the gas to the places where it is to be used. If the main sends off branches for burners, then for the same length the diameter may be reduced, or for like diameter the length may be greater. For example, if a pipe of 5·32 inches, which transmits 2000 cubic feet through a length of 2000 feet, gives off, in this space, 1000 cubic feet of gas; then the remainder of the pipe, having the same diameter, can continue to transmit the gas through a length of 2450 feet $= \left(\dfrac{450,000}{k}\right)$s with undiminished pressure for the purposes of lighting. Inversely, the diameter should be progressively reduced in proportion to the number of jets sent off in the length of the pipe.

Suppose, for instance, the gasometer to discharge 2000 cubic feet per hour, and the last point of the jets to be at a distance of 4000 feet. Suppose also that from the gasometer to the first point of lighting, the gas proceeds through 1000 feet of close pipe, the diameter of the pipe will be here 4·47 inches; in the second 1000 feet of length, suppose the pipe to give off, at equal distances, 1000 cubic feet of gas, the diameter in this length (calculated at 1500 cubic feet for 1000 feet long) = 3·87 inches; in the third extent of 1000 feet, 600 cubic feet of gas will be given off, and the diameter (reckoning 700 cubic feet for 1000 feet long) will be 2·65 inches; in the fourth and last space (for 200 cubic feet in 1000 feet long) the pipe has a diameter of only an inch and a half, for which, in practice, a two-inch cast iron pipe is substituted; this being the smallest used in mains, into which branch pipes can be conveniently inserted.

The same relations hold with regard to branch pipes through which the gas is transmitted into buildings and other places to be illuminated. If such pipes make frequent angular turnings, whereby they retard the motion of the gas, they must be a third or a half larger in diameter. The smallest tubes of distribution are never less than one fourth of an inch in the bore.

Where, from one central gas work, a very great quantity of light is required in particular localities, there ought to be placed near these spots gasometers of distribution, which, being filled during the slack hours of the day, are ready to supply the burners at night, without making any considerable demand upon the original main pipe. Suppose the first main be required to supply 8000 cubic feet in the hour, for an illumination of 8 hours, at the distance of 2000 feet, a pipe 10¾ inches in diameter would be necessary; but if two or three gasometers of distribution, or station gasometers, be had recourse to, into which the gas during the course of 24 hours would flow through the same distance continuously from the central gas works, the quantity required per hour from them would be only one third of 8,000 = 2666·6 cubic feet; consequently the diameter for such a pipe is only 6·15 inches.

All the principal as well as branch pipes, whose interior diameter exceeds an inch and a half, are made of cast iron from 6 to 8 feet long, with elbow pipes cast in them where it is necessary. These pipe lengths are shown in fig. 492, having at one end a wide socket a, and at the other a nozzle b, which fits the former. After inserting the one in the other in their proper horizontal position, a coil of hemp soaked with tar is driven home at the junction; then a luting of clay is applied at the mouth, within which a ring of lead is cast into the socket, which is driven tight home with a mallet and blunt chisel.

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493
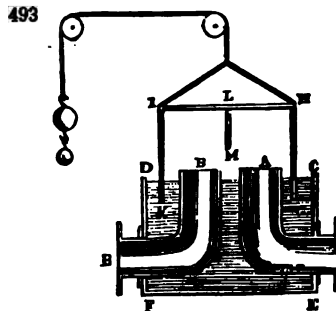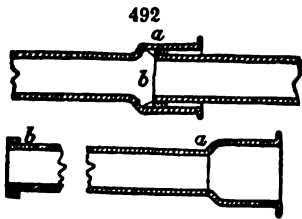
The pipes should be proved by a force pump before being received into the gas works; two or three lengths of them should be joined before laying them down, and they should be placed at least two feet below the surface, to prevent their being affected by changes of temperature, which would loosen the joints. The tubes for internal distribution, when of small size, are made of lead, copper, wrought iron, or tin.

Instead of a stopcock for letting off the gas in regulated quantities from the gas-ometer, a peculiarly formed water or mercurial valve is usually employed. *Fig.* 493 shows the mode of construction for a water trap or lute, and is, in fact, merely a gas-ometer in miniature. C D E F is a square cast iron vessel, in the one side of which a pipe A is placed in communication with the gasometer, and in the other, one with the main B. The moveable cover or lid H G I K has a partition, L M, in its middle. If this cover is raised by its counterweight, the gas can pass without impediment from A to B; but if the counterweight be diminished so as to let the partition plate L M sink into the water, the communication of the two pipes is thereby interrupted. In this case the water-level stands in the compartment A so much lower than outside of it, and in the compartment B, as is equivalent to the pressure in the gasometer; therefore the pipes A and B must project thus far above the water. In order to keep the water always at the same height, and to prevent it from flowing into the mouths of these pipes, the rim C D of the outer vessel stands somewhat lower than the orifices A B; and thence the vessel may be kept always full of water.

If a quicksilver valve be preferred, it may be constructed as shown in *fig.* 494. A B are the terminations of the two gas pipes, which are made fast in the rectangular iron vessel M. E is an iron vessel of the same form, which is filled with quicksilver up to the level a, and which, by means of the screw G, which presses against its bottom, and works in the fixed female screw C C, may be moved up or down, so that the vessel E may be immersed more or less into the quicksilver. The vessel E is furnished with a vertical partition m; the passage of the gas from A to B is therefore obstructed when this partition dips into the quick-silver, and from the gradual depression of the vessel E by its screw, the interval be-tween the quicksilver and the lower edge of the partition, through which the gas must enter, may be enlarged at pleasure, whereby the pressure of the gas in B may be regulated to any degree. The trans-verse section of that interval is equal to the area of the pipe or rather greater; the breadth of the vessel M from A to B amounts to the double of that space, and its length to the mere diameter of A or B. The greatest height to which the partition m can rise out of the quicksilver, is also equal to the above diameter, and in this case the line a comes to the place of b. The vertical movement of the outer vessel E, is secured by a rectangular rim or hoop which surrounds it, and is made fast to the upper part of the vessel M, within which guide it moves up and down. Instead of the lever D D, an index with a graduated plate may be employed to turn the screw, and to indicate exactly the magnitude in the opening of the valve.

In order to measure the quantity of gas which passes through a pipe for lighting a factory, theatre, &c., the gas-meter is em-ployed, of whose construction a sufficiently precise idea may be formed from the con-sideration of *fig.* 495, which shows the in-strument in a section perpendicular to its axis.

Within the cylindrical case a, there is a shorter cylinder b b, shut at both ends, and moveable round an axis, which is divided into four compartments, that communicate by the opening d, with the interval between this cylinder and the outer case The mode in which this

cylinder turns round its axis is as follows :—The end of the tube *c*, which is made fast to the side of the case, and by which the gas enters, carries a pivot or gudgeon, upon which the centre of its prop turns; the other end of the axis runs in the cover, which here forms the side of a superior open vessel, in which, upon the same axis, there is a toothed wheel. The vessel is so far filled with water, that the tube *c* just rises above it, which position is secured by the level of the side vessel. When the gas enters through the tube *c*, by its pressure upon the partition *e* (*fig.* 495), it turns the cylinder from right to left upon its axis, till the exterior opening *d* rises above the water, and the gas expands itself in the exterior space, whence it passes off through a tube at top. At every revolution, a certain volume of gas thus goes through the cylinder, proportional to its known capacity. The wheel on the axis works in other toothed wheels, whence, by means of an index upon a graduated disc or dial, placed at the top or in front of the gas-meter, the number of cubic feet of gas, which pass through this apparatus in a given time, is registered.

B. *Employment of the gas for lighting.*—The illuminating power of different gases burned in the same circumstances, is proportional, generally speaking, to their specific gravity, as this is to the quantity of carbon they hold in combination. The following table exhibits the different qualities of gases in respect to illumination.

Density or specific gravity.		Proportion of light afforded by coal gas to oil gas.
Coal gas.	Oil gas.	
0·659	0·818	100 : 140
0·578	0·910	100 : 225
0·605	1·110	100 : 250
0·407	0·940	100 : 354
0·429	0·965	100 : 356
0·508	1·175	100 : 310
Mean 0.529	0·96	100 : 272

In the last three proportions, the coal gas was produced from coals of middle quality; in the first three proportions, from coals of good quality; and therefore the middle proportion of 100 to 270 may be taken to represent the fair average upon the great scale. On comparing the gas from bad coals, with good oil gas, the proportion may become 100 to 300. Nay, coal gas of specific gravity 0·4, compared to oil gas of 1·1, gives the proportion of 1 to 4. A mould tallow candle, of 6 in the pound, burning for an hour, is equivalent to half a cubic foot of ordinary coal gas, and to four tenths of a foot of good gas. The flame of the best argand lamp of Carcel, in which a steady supply of oil is maintained by pump-work, consuming 42 grammes = 649 grains English in an hour, and equal in light to 9·38 such candles, is equivalent to 3·75 cubic feet of coal gas per hour. The sinumbra lamp, which consumes 50 grammes = 772 grains English, of oil per hour, and gives the light of 8 of the above candles, is equivalent to the light emitted by 3·2 cubic feet of coal gas burning for an hour. A common argand lamp, equal to 4 candles, which consumes 30 grammes = 463 grains English per hour, is represented by 1·6 cubic feet of gas burning during the same time. A common lamp, with a flat wick and glass chimney, whose light is equal to 1·13 tallow candles, and which consumes 11 grammes = 169·8 grains English per hour, is represented by 0·452 of a cubic foot of gas burning for the same time.

Construction of the Burners.—The mode of burning the gas as it issues from the jets has a great influence upon the quantity and quality of its light. When carbureted hydrogen gas is transmitted through ignited porcelain tubes, it is partially decomposed with a precipitation of some of its carbon, while the resulting gas burns with a feebler flame. Coal gas, when kindled at a small orifice in a tube, undergoes a like decomposition and precipitation. Its hydrogen, with a little of its carbon, burns whenever it comes into contact with the atmospherical air, with a bluish colored flame; but the carbonaceous part not being so accendible, takes fire only when mixed with more air; therefore at a greater distance from the beak, and with a white light from the vivid ignition of its solid particles. Upon this principle pure hydrogen gas may be made to burn with a white instead of its usual blue flame, by dusting into it particles of lamp black, or by kindling it at the extremity of a tube containing finely pulverized zinc. The metallic particles become ignited, and impart their bright light to the pale blue flame. Even platinum wire and asbestos, when placed in the flame of hydrogen gas, serve to whiten it. Hence it has been concluded, that the intensity of light which a gas is capable of affording is proportional to the quantity of solid particles which it

contains, and can precipitate in the act of burning. Carbonic oxyde gas burns with the feeblest light next to hydrogen, because it deposites no carbon in the act of burning. Phosphureted hydrogen gives a brilliant light, because the phosphoric acid, into which its base is converted during the combustion, is a solid substance, capable of being ignited in the flame. Olefiant gas, as also the vapor of hydro-carbon oil, emits a more vivid light than common coal gas; for the first is composed of two measures of hydrogen and two measures of the vapor of carbon condensed into one volume; while the last contains only one measure of the vapor of carbon in the same bulk, and combined with the same proportion of hydrogen. Olefiant gas may therefore be expected to evolve a double quantity of carbon in its flame, which should emit a double light.

The illuminating power of the flame of coal gas is, on the contrary, impaired, when, by admixture with other species of gas which precipitate no carbon, its own ignited particles are diffused over a greater surface. This happens when it is mixed with hydrogen, carbonic oxyde, carbonic acid, and nitrogen gases, and the diminution of the light is proportional to the dilution of the coal gas.

In like manner the illuminating power of coal gas is impaired, when it is consumed too rapidly to allow time for the separation and ignition of its carbonaceous matter; it burns, in this case, without decomposition, and with a feeble blue flame. 1. This occurs when the light-gas is previously mixed with atmospherical air, because the combustion is thereby accelerated throughout the interior of the flame, so as to prevent the due separation of carbon. A large admixture of atmospherical air makes the flame entirely blue. 2. When it issues, with considerable velocity, from a minute orifice, whereby the gas, by expansion, gets intimately mixed with a large proportion of atmospherical air. If the jet be vertical, the bottom part of the flame is blue, and the more so the less carbon is contained in the gas. The same thing may be observed in the flame of tallow, wax, or oil lights. The burning wick acts the part of a retort, in decomposing the fatty matter. From the lower part of the wick the gases and vapors of the fat issue with the greatest velocity, and are most freely mixed with the air; while the gases disengaged from the upper part of the wick compose the interior of the flame, and being momentarily protected from the action of the atmosphere, acquire the proper high temperature for the deposition of carbon, which is then diffused on the outer surface in an ignited state, and causes its characteristic white light. Hence with coal gas, the light increases in a certain ratio with the size of the flame as it issues from a larger orifice, because the intermixture of air becomes proportionately less. 3. If by any means too great a draught be given to the flame, its light becomes feebler by the rapidity and completeness with which the gas is burned, as when too tall a chimney is placed over an argand burner, see *fig.* 496. *Fig.* 497, *c*, is a view of the upper plate, upon which the glass chimney *b* rests. The gas issues through the smaller openings of the inner ring, and forms a hollow cylindrical flame, upon the outside as well as the inside of which the atmospherical air acts. The illuminating power of this flame may be diminished at pleasure, according as more or less air is allowed to enter through the orifices beneath. With a very full draught the light almost vanishes, leaving only a dull blue flame of great heating power, like that of the blowpipe, corresponding to the perfect combustion of the gas without precipitation of its carbon. 4. On the other hand, too small a draught of air is equally prejudicial; not merely because a portion of the carbon thus escapes unconsumed in smoke, but also because the highest illuminating power of the flame is obtained only when the precipitated charcoal is heated to whiteness; a circumstance which requires a considerable draught of air. Hence the flame of dense oil gas, or of oil in a wick, burns with a yellow light without a chimney; but when it is increased in intensity by a chimney draught, it burns with a brilliant white flame.

From the consideration of the preceding facts, it is possible to give to coal gas its highest illuminating power. The burners are either simple beaks perforated with a small round hole, or circles with a series of holes to form an argand flame, as shown in *fig.* 497, or two holes drilled obliquely, to make the flame cross, like a swallow's tail, or with a slit constituting the sheet of flame called a bat's wing, like most of the lamps in the streets of London. These burners are mounted with a stopcock for regulating the quantity of gas.

The height of the flame, which with like pressure depends upon the size of the orifice, and with like orifice upon the amount of pressure, the latter being modified by the stopcock, is, for simple jets in the open air, as follows :—

Length of the flame	2	3	4	5	6 inches.
Intensity of the light	55·6	100	150	197·8	247.4
Volume of gas consumed	60·5	101·4	126·3	143·7	182·2
Light with equal consumption	100	109	131	150	150

When the length exceeds five inches, nothing is gained in respect to light. For oil

gas the same statements will serve, only on account of its superior richness in carbon, it does not bear so long a flame without smoke. Thus:

Length of the flame	1	2	3	4	5 inches.
Intensity of the light	22	63·7	96·5	141	178
Gas consumed	33·1	78·5	90	118	153
Light with equal consumption	100	122	159	181	174

The diameter of the orifice for single jets, or for several jets from the same beak, is one twenty-eighth of an inch for coal gas, and one forty-fifth for oil gas.

When several jets issue from the same burner, the light is improved by making all the flames unite into one. In this case the heat becomes greater, for the combined flame presents a smaller surface to be cooled, than the sum of the smaller flames. The advantage gained in this way may be in the ratio of 3 to 2, or 50 per cent. In an argand burner the distances of the orifices for coal gas should be from $\frac{16}{100}$ to $\frac{18}{100}$ of an inch, and for oil gas $\frac{12}{100}$. If the argand ring has 10 orifices, the diameter of the central opening should be $= \frac{4}{10}$ of an inch; if 25 orifices, it should be one inch for coal gas; but for oil gas with 10 orifices, the central opening should have a diameter of half an inch, and for 20 orifices, one inch. The pin holes should be of equal size, otherwise the larger ones will cause smoke, as in an argand flame with an uneven wick. The glass chimney is not necessary to promote the combustion of an argand coal gas flame, but only to prevent it from flickering with the wind, and therefore it should be made so wide as to exercise little or no influence upon the draught. A narrow chimney is necessary merely to prevent smoke, when a very strong light with a profusion of gas is desired. Oil gas burned in an argand beak requires a draught chimney, like a common argand lamp, on account of the large quantity of carbon to be consumed. The most suitable mode of regulating the degree of draught can be determined only by experiment, and the best construction hitherto ascertained is that represented in *fig.* 498. *Fig.* 499 exhibits the
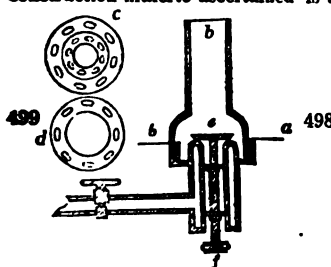
view from above, of the rim or ring c, upon which the chimney b stands, and which surrounds the perforated beak. The ring is made of open fretwork, to permit the free passage of air upwards to strike the outside of the flame. The thin annular disc d, which is laid over its fellow disc c, in the bottom of the chimney-holder, being turned a little one way or other, will allow more or less air to pass through for promoting, more or less, the draught or ventilation. The draught in the central tube of the burner may be regulated by the small disc e, whose diameter is somewhat smaller than that of the ring of the burner, and which, by turning the milled head f, of the screw, may be adjusted with the greatest nicety, so as to admit a greater or smaller body of air into the centre of the cylindrical flame.

In mounting gas-lights, and in estimating beforehand their illuminating effects, we must keep in mind the optical proposition, that the quantity of light is inversely as the square of the distance from the luminous body, and we must distribute the burners accordingly. When, for example, a gas-light placed at a distance of ten feet, is required for reading or writing to afford the same light as a candle placed at a distance of two feet; squaring each distance, we have 100·4; therefore $\frac{100}{4} = 25$, shows us that 25 such lights will be necessary at the distance of 10 feet.

Concerning portable gas-light, with the means of condensing it, and carrying it from the gas works to the places where it is to be consumed, we need say nothing, as by the improvements lately made in the purification and distribution of coal gas, the former system has been superseded.

It is well known that light gas deteriorates very considerably by keeping, especially when exposed to water over an extensive surface; but even to a certain degree over oil, or in close vessels. An oil gas which when newly prepared has the specific gravity of 1·054, will give the light of a candle for an hour, by consuming 200 cubic inches; will, after two days, give the same light by consuming 215 cubic inches per hour; and after four days, by consuming 240 cubic inches in the like time. With coal gas the deterioration appears to be more rapid. When newly prepared, if it affords the light of a candle with a consumption of 400 cubic inches per hour, it will not give the same light after being kept two days, except with a consumption of 430 inches; and after four days, of 460. Oil gas three weeks old has become so much impaired in quality that 600 inches of it were required per hour to furnish the light of a candle. All light gas should be used therefore as soon as possible after it is properly purified.

Economical considerations.—The cost of gas-light depends upon so many local circumstances, that no estimate of it can be made of general application; only a few

leading points may be stated. The coals required for heating the retorts tend to constitute one half of the quantity required for charging the retorts themselves. When five retorts are heated by one fire, the expenditure for fuel is only one third of that when each retort has a fire. The coke which remains in the retorts constitutes about 60 per cent. of the weight of the original coal; but the volume is increased by the coking in the proportion of 100 to 75. When the coke is used for heating the retorts, about one half of the whole is required. If we estimate the coke by its comparative heating power, it represents 45 per cent. of the coals consumed. One hundred pounds of good coal yield in distillation 10 pounds of ammoniacal liquor, from which sulphate or muriate of ammonia may be made, by saturation with sulphuric or muriatic acid, and evaporation. The liquor contains likewise some cyanide of ammonia, which may be converted into Prussian blue by the addition of sulphate of iron, after saturation with muriatic acid.

Two hundred pounds of coal afford about 17 pounds of tar. This contains in 100 pounds 26 pounds of coal oil, and 48 pounds of pitch. The tar is sometimes employed as a paint to preserve wood and walls from the influence of moisture, but its disagreeable smell limits its use. The coal oil, when rectified by distillation, is extensively employed for dissolving caoutchouc in making the varnish of waterproof cloth, and also for burning in a peculiar kind of lamps under the name of naptha. Oil of turpentine, however, is often sold and used for this purpose, by the same name. If the coal oil be mixed with its volume of water, and the mixture be made to boil in a kettle, the mingled vapors when passed through a perforated nozzle may be kindled, and employed as a powerful means of artificial heat. The water is not decomposed, but it serves by its vapor to expand the bulk of the volatile oil, and to make it thereby come into contact with a larger volume of atmospherical air, so as to burn without smoke, under a boiler or any other vessel. The pitch may be decomposed into a light-gas.

The relative cost of light from coal gas and oil gas may be estimated as one to six at least. Rosin gas is cheaper than oil gas. See ROSIN.

I shall conclude this article with a summary of the comparative expense of different modes of illumination, and some statistical tables.

One pound of tallow will last 40 hours in six mould candles burned in succession, and costs 8d.; a gallon of oil, capable of affording the light of 15 candles, for 40 hours, costs 5s.; being therefore $\frac{1}{8}$ of the price of mould candles, and $\frac{9}{16}$ of the price of dips. The cost of wax is about $3\frac{1}{2}$ times that of tallow; and coal gas, as sold at the rate of 9s. for 1000 cubic feet, will be one sixth the price of mould candles; for 500 cubic inches of coal gas give a light equal to the above candle for an hour; therefore $40 \times 500 = 20,000$ cubic inches $= 11.57$ cubic feet, worth $1\frac{1}{4}d.$, which multiplied by 6 gives $7\frac{1}{2}d.$, the average price of mould candles per pound.

The author of the article Gas-light in the Encyclopædia Britannica, observes, in reference to the economy of this mode of illumination, that while the price of coal, in consequence of the abundant and regular supply of that article, is liable to little fluctuation, the cost of wax, tallow, and oil, on account of the more precarious nature of the sources from which they are obtained, varies exceedingly in different seasons. "Assuming that a pound of tallow candles, which last when burned in succession forty hours, costs nine-pence" (seven-pence halfpenny is the average price), "that a gallon of oil, yielding the light of 600 candles for an hour, costs two shillings" (five shillings is the lowest price of a gallon of such oil as a gentleman would choose to burn in his lamp), "that the expense of the light from wax is three times as great as from tallow, and that a thousand cubic feet of coal gas cost nine shillings;" he concludes the relative cost to be for the same quantity of light,—from wax, 100; tallow, 25; oil, 5; and coal-gas, 3. I conceive the estimate given above to be much nearer the truth; when referred to wax called 100, it becomes, for tallow, 28.6; oil, 14.3; coal-gas, 4.76.

Gas-lighting has received a marvellous development in London. In the year 1834, the number of gas lamps in this city was 168,000, which consumed daily about 4,200,000 cubic feet of gas. For the purpose of generating this gas, more than 200,000 chaldrons, or 10,800,000 cubic feet of coals were required.

For the following valuable statistical details upon gas-light, my readers are indebted to Joseph Hedley, Esq., engineer, of the Alliance Gas Works, Dublin; a gentleman who to a sound knowledge of chemistry, joins such mechanical talent and indefatigable diligence, as qualify him to conduct with success any great undertaking committed to his care. He has long endeavored to induce the directors of the London gas-works to employ a better coal, and generate a more richly carbureted gas, which in much smaller quantity would give as brilliant a light, without heating the apartments unpleasantly, as their highly hydrogenated gas now does. Were his judicious views adopted, coal gas would soon supersede oil, and even wax candles, for illuminating private mansions.

f a paper laid before a Committee of the House of Commons, showing not only
ve values of the Gases produced at the undermentioned places, but showing in
ner the relative economy of Gas, as produced at the different places, over can-
r Joseph Hedley, Esq.

nes Places xeriments made.	Illuminating power of a single Jet of Gas-flame four inches high, taken by a comparison of Shadows.	The Jet of Gas burnt, four inches high, consumed per hour and was equal to the Candles in the last column.	Gas required to be equal to 100 lbs. of mould Candles, 6 to the lb., 9 inches long each.	Selling price of Gas per meter per 1000 cubic feet.	Cost of Gas equal in illuminating power to 100 lbs. of Candles.†	Average discount allowed off the charge for Gas.	Net cost of Gas equal to 100 lbs. of Candles.	Specific gravity of the Gas.
	Equal to Candles.	Cubic Feet.	Cubic Feet.	s. d.	L. s. d.	PerCent.	L. s. d.	
am ; am and ure ; panies	2·572	1·22	2704	10 0	1 7 0	0	1 4 7	·541
er	2·254	·85	1489	10 0	0 14 11	12½	0 13 0	·539
Old	3·060	·825	1536	8 0	0 12 3	11½	0 10 10	·534
ryt	2·209	1·1	2646	10 0	1 6 5	6½	1 4 9	·462
New mpany	4·408	·9	1164	10 0	0 11 8	6½	0 9 10	·560
	2·190	1·2	3123	9 0	1 8 1	12½	1 4 6	·420
	2·970	·855	1644	8 0	0 13 2	6½	0 12 4	·530
	2·434	1·04	2440	8 0	0 19 6	6½	0 18 2	·466
um	2·435	1·1	2575	7 6	0 19 3	15	0 16 5	·528
	1·645	1·3	4200	9 0	1 17 9	15	1 11 3	·424
	1·937	1·2	3521	10 0	1 15 4	15	1 10 0	·448
	2·136	1·15	3069	10 0	1 10 8	15 none allowed	1 6 2	·419
	2·083	1·13	3092	10 0	1 10 11		1 10 11	·412

s. of candles are estimated to burn 5700 hours. † The candles cost 3l. 2s. 6d.
.iverpool Old Company have since resorted to the use of Cannel coal, and consequently very nearly
i to the Liverpool New Company in illuminating power.

NDUM.—It will not fail to be observed that in deducing the comparative value
:n candles and gas by these experiments, the single jet (and in every instance,
rse, it was the same) has been the medium. This, however, though decidedly
st correct way of making the comparative estimate of the illuminating power of
veral gases, is highly disadvantageous in the economical comparison, inasmuch
 burnt in a properly regulated argand burner, with its proper sized glass, air
re, and sufficient number of holes, gives an advantage in favor of gas consumed
irgand, over a jet burner, of from 30 to 40 per cent. At the same time it must
 overlooked, that in many situations where great light is not required, it will be
 far more economical to adopt the use of single jets, which, by means of swing
ts and light elegant shades, become splendid substitutes for candles, in banking
shments, offices, libraries, &c. &c.
:n Glasgow, Edinburgh, Dundee, Perth, and the Scotch towns generally, the
 or Scotch Cannel coal is used ; in illuminating power and specific gravity the
 oduced is equal to that from the best description of Cannel coal in England.
ice per 1000 cubic feet ranges about 9s., with from 5 to 30 per cent. off for dis-
, leaving the net price about 9s. to be equal in the above table to 100 lbs. of
i.

ie of Experiments made in Gas produced from different qualities of Coal, and
l in different kinds of Burners :
 the Sheffield Gas Light Company's Works, and laid before a Committee of the
House of Commons. By Joseph Hedley, Esq.

scription Burner.	Species of Coal.	Specific gravity of Gas.	Distance of Candle from Shadow.	Gas consumed per Hour.	Height of Gas Flame.	Equal to Mould Tallow Candles, 6 to the pound, 9 inches long each.	Gas equal to 100 lbs. of Mould Candles.	Cost of Gas at 8s. per 1000 cubic feet.	Cost of 100 lbs. of Mould Candles at 7s. 6d. per dozen lbs.
			Inches	Cubic Feet.	Inches	Candles.	Cubic Feet.	L. s. d.	L. s. d.
le Jet	Deep Pit	·410	75	1·	4	2·36	2415	0 19 3½	
to	Mortormley	·450	74	·95	4	2·434	2294	0 17 9½	
to	Cannel	·660	61¼	·7	4	3·54	1127	0 9 0	3 2 6
rgand holes	Deep Pit	·410	34	3·3	3½	11·53	1631	0 13 0½	
to	Mortormley	·450	33	3·1	3½	12·24	1443	0 11 5½	
to	Cannel	·660	29	2·6	3½	15·85	935	0 7 5½	

Copy of Experiments made at the Alliance Gas Company's Works in Dublin, during the
past year 1837. By Joseph Hedley, Esq.

Results of experiments on the qualities of various coals for the production of gas; its
value in illuminating power; produce of coke, and quality; and other particulars important in gas-making :—

1st *Experiment, Saturday, May 27, 1837.*—Deane coal (Cumberland), 2 cwts. of 112
lbs. each (or 224 lbs.) produced 970 cubic feet of gas; 4 bushels of coke of middling
quality; specific gravity of the gas, 475. Consumed in a single-jet burner, flame 4
inches high, $1\frac{4}{10}$ths cubic feet per hour; distance from shadow 76 inches, or 2·3
mould candles. Average quantity of gas made from the charge (6 hours) 4·33 cubic feet
per lb., or 9,700 cubic feet per ton of 20 cwts. Increase of coke over coal in measure, not
quite 30 per cent. Loss in weight between coal, coke, and breize 56 lbs., converted
into gas, tar, ammonia, &c.

2d *Experiment, May 28.*—Carlisle coal (Blenkinsopp). 224 lbs. produced 1010 cubic
feet of gas, 4 bushels of coke of good quality though small; increase of coke over coal in
measure not quite 30 per cent. Loss in weight, same as foregoing experiment. Average
quantity of gas made from the charge (6 hours) 4·5 cubic feet per lb. or 10,080 per ton.

Illuminating power of the Gas.

	Consumed per hour, single jet.	Distance from candle.	Equal to candles.	Specific gravity.
	feet.	*inches.*		
At the end of the first hour - -	$1\frac{1}{10}$	70	2·72	·475
Ditto ditto with 20-hole argand burner - -	5	25	21·33	·475
When charge nearly off - -	$1\frac{4}{10}$	85	1·84	·442
When charge quite off, with 20-hole argand burner - -	9	100	not 1	·266

3d *Experiment, May 29.*—Carlisle coal (Blenkinsopp). 112 lbs. produced 556 cubic
feet of gas. Other products, loss of weight, &c., same proportion as foregoing experiment. Average quantity of gas made from the charge (6 hours) 4·96 cubic feet per lb.,
or 11,120 per ton.

In this experiment the quantity of gas generated every hour was ascertained; the
illuminating power, the specific gravity, and the quantity of gas consumed by the single
jet with a flame 4 inches high, was tried at the end of each hour, with the respective
gases generated at each hour; and the following is a table of results.

RESULTS.

Hour.	Gas produced.	Consumed per hour, per single jet, 4 inches high.	Specific gravity.	Distance of candle from shadow.	Illuminating power equal to mould candles.
	cubic feet.	*cubic feet.*		*inches.*	
1st.	150	$11\frac{1}{2}$-10ths or 1·15	·534	70	2·72
2d.	120	11	·495	75	2·36
3d.	95	12	·344	75	2·36
4th.	95	15	·311	80	2·08
5th.	80	17	·270	85	1·81
6th.	16	29	·200	100	not one
Total	556 or	$92\frac{1}{2}$ or 2	feet 9 inches.		

Average of the above gas, 6-hour charge.
$92\frac{1}{2}$ 16-10ths, nearly   ·359   81   2·03

Average of the above gas at 4-hour charge.
115          $12\frac{1}{2}$-10ths,   ·421   75   2·36

Production of gas in 6 hours 556 feet, or at the rate of 11,120 cubic feet per ton.
Ditto   in 4 hours 460 feet, or at the rate of 9,200   ditto

The relative value of these productions of gas is as follows, viz. :

11,120 at 16-10ths per hour nearly (or 1·5916 accurately), and equal to 203 candles; the 11,120 feet would be equal to and last as long as 1597 candles, or 266½ lbs. of candles.

9200 at 12½-10ths per hour (or 1·2375 accurately), and equal to 236 candles; the 9200 feet would be equal to 1949 candles, or 324⅚ lbs. candles.

Now 266½ lbs. of mould candles, at 7s. 6d. per dozen lbs., will cost 8l. 6s. 4½d., whilst 324⅚ lbs. of do. do. at 7s. 6d. per do. do. 10l. 3s.

Showing the value of 4-hour charges over 6-hour charges; and of 9,200 cubic feet over 11,120 cubic feet.

Note.—9500 cubic feet of Wigan cannel coal gas are equal in illuminating power to 859 1-6th lbs. of candles, which at 7s. 6d. per dozen lbs. will cost 25l. 10s. 5½d. It is also found that any burner with superior gas will consume only about half the quantity it would do with common gas.

4th Experiment, May 30th.—Cannel and Cardiff coal mixed ½ and ½, together 112 lbs., produced 460 feet of gas; 2 bushels of coke of good quality; increase of coke over coal in measure, about 30 per cent.; loss in weight, 41 lbs.; coke weighed 71 lbs., no breize. Average quantity of gas made from the charge (4 hours), 4·1 cubic feet per lb., or 9·200 per ton.

Illuminating power.—At the end of the first hour.

	Candles.		Cubic feet.
Distance of candle from shadow - - -	73 or 2·49	Consumed per hour, single jet, 4 inches high -	12-10ths.
At end of 2d hour, do.	70 or 2·72	Do. do. do.	11½-10ths.
At end of 3d hour.	This gas very indifferent.		
Average of the three -	70 or 2·72	Do. do. do.	11½-10ths.

Specific gravity 3·44; 5 feet per hour, with a 20-hole argand burner, equal to 14·66 candles.

5th Experiment, May 31st.—Carlisle coal, 112 lbs. produced 410 feet of gas; other products, same as in former experiments with this coal, but heat very low.

Illuminating power and produce of gas.

410 ft. { 1st hour 120 cubic feet / 2d 100 / 3d 90 / 4th 100 }

{ Average of this gas: specific gravity, 540; distance of candle from shadow, 55 inches, or 4·4 candles consumed per single jet, 9-10ths of a cubic foot per hour. 20-hole argand burner, 4 feet per hour, equal to 21·33 candles. }

It is possible, from the superior quality of this gas, that a little of the cannel gas made for a particular purpose, may have got intermixed with it in the experimental gasholder and apparatus.

A variety of other experiments were tried on different qualities of coal, and mixtures of ditto, too tedious to insert here, though extremely valuable, and all tending to show the superior value of gas produced at short over long charges; and also showing the importance and value of coal producing gas of the highest illuminating power; among which the cannel coal procured in Lancashire, Yorkshire, and some other counties of England and Wales, and the Parrot or splent coal of Scotland, stand pre-eminent.

Note.—In all the foregoing experiments the same single-jet burner was used; its flame in all instances exactly 4 inches high.

The coal when drawn from the retort was slaked with water, and after allowing some short time for drying, was weighed.

A TABLE of the number of hours Gas is burnt in each month, quarter, and year.

Time of Burning.	July.	August.	Sept.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Mid. quar.	Mic. quar.	Xmas quar.	Lady day quar.	Total of year.	
o'clock.																		deduct
From dusk to 6	—	—	2	3½	62	80	65	33	4	—	—	—	2	179	102	277	
— 7	—	14	22	62	92	111	96	61	31	4	—	4	36	265	184	493	
— 8	—	40	52	93	132	112	127	89	62	28	4	32	92	357	278	759	
— 9	13	71	82	124	152	173	158	117	93	58	29	8	95	156	449	368	1078	
— 10	44	102	112	155	182	204	182	145	124	88	60	38	186	258	541	458	1443	
— 11	75	133	142	186	212	235	220	173	155	118	91	68	277	350	633	548	1808	
— 12	106	164	172	217	242	266	251	201	186	148	122	98	368	442	725	638	2173	
All night -	217	307	345	431	473	527	512	411	382	295	242	195	732	860	1431	1305	4327	
Morning from 4	—	16	48	80	110	137	137	98	71	28	2	—	30	64	327	308	727	
— 5	—	—	18	49	80	106	106	70	40	3	—	—	3	18	235	216	473	
— 6	—	—	—	18	50	75	75	42	9	—	—	—	—	—	143	126	269	
— 7	—	—	—	—	20	44	44	14	—	—	—	—	—	—	64	58	122	

Copy of a Paper submitted to a Committee of the House of Commons in the Session of 1837, of England; and procured by actual Survey and

Name of the Place where Gas Works are situated.	Price of Gas per Meter, and Discounts allowed.	Price of Coal, and Description; delivered per Ton.	Average Quantity of Gas made per Ton of Coal.	Coke made from a Ton of Coal.	Selling Price of Coke.	Material used to heat Retorts.	Quantity used per Ton of Coal.	No. of Public or Street Lamps supplied.	Description — Size or Sort.	Price paid per Annum for Ditto.	Who lights, cleans, primes, and repairs.
			Cub./ft.							£. s. d.	
Birmingham Gas Company.	10s. per meter cub. feet. Discounts 10l. to 30l. 2½; 30l. to 50l. 5; 50l. to 75l. 7½ per cent.; 75l. to 100l. 10; 100l. & upwards 15	Lump coal from West Bromwich pits, risen much of late, 1837, 11s. 10d.	6,300	32 bushels.	2s. 1d. per quarter delivered, or about 3d. per bushel.	Slack.	About 8 cwt. of slack, at 6s. per ton, 16 per cent.	430	Batswings. 432 36	1 10 0 / 2 2 0	Company, and provides post, services, &c.
Birmingham and Staffordshire.	10s. per meter cub. feet. Discounts as above.	From West Bromwich pits, 1837, 9s. 2d.	6,500	24 bush. but larger measure than Birmingham.	2s. 10d. per sack of 8 bushels.	Slack and Tar.	8 cwt. of slack, at 4s. 21 per cent.	1,009	Batswings.	average 1 13 0	Ditto.
Macclesfield.	10s. per meter cub. feet. Discounts 30l. 7s. 5; 75l. 100l. 7½; 100l. 125l. 10; 125l. 150l. 12½; 150l. 175l. 15; 175l. 200l. 17½; 200l. & upwards 20	Common, 8s. average 1834.	6,730	12 cwt.	10s. per ton.	Coke.	No account kept.	220	Ditto.	2 10 0	Company.
Stockport.	10s. per meter cub. feet. Disc'ts same as Macclesfield. Macclesfield discounts taken from Stockport card.	Coal 10s. 6d. cannel 19s.6d. about half and half used. Average 15s. 1834.	7,800	7 cwt.	6s. 3d. per ton.	Coal, coke, and tar.	Ditto.	220	Ditto.	2 10 0 1834. 2 0 0 1837.	Contrs. provide lamps & posts. Company's service light, repair, clean, and extinguish.
Manchester.	10s. per m.cub.ft. 1834. 9s. and 8s. 1837. Discounts 50l. 100l. 2½; 100l. 150l. 5; 150l. 200l. 7½; 200l. 225l. 10; 225l. 250l. 12½; 250l. 300l. 15; 300l. 400l. 17½; 400l. & upwards 20	12s. 6d. average. Oldham Water-gate } cannel Wigan Mixed, 1834.	9,500	14 cwt.	Ditto.	Coke.	4, 2-3ds cwt.	2,375	Single jets and flat flames, about half and half.	1 1 0 / 2 0 0	Company.
Liverpool Old Company, 1834.	10s. per meter cub. feet. Discounts 10l. & under 50l. 2½; 50l. to 100l. 5; 100l. to 300l. 7½; 300l. and upwards 10	7s. 3d. per ton of 112 lbs. per cwt. Ormskirk or Wigan slack.	8,500	11½ cwt.	2s. 4d. per ton of 112 lb. per cwt.	Slack, 7s. 3d. per ton.	6½ cwt.	1,700 30	Batswings. 1 jet, 2 — 3 — 4 —	4 10 0 / 3 5 / 3 12 / 3 0 / 3 15 11	Company light, clean, repair, and post.
Ditto, ditto, Liverpool New Gas and Coke, 1833.	10s. per meter cub. feet. Discounts same as Liverpool Old Comp'ny.	resorted to the use of cannel coal since 1835, 18s. all cannel Wigan.	9,500	13 cwt.	coal similar to the Liverpool, 7s. 6d. per ton.	Coke and slack.	2½ cwt.	New Gas Only a few.	Coal and Coke Argands.	Company, prolong 4 0 0	Consumers.
Bradford, 1834.	9s. per meter cubic feet to large consumers. Discounts 20l. to 30l. 5; 30l. to 40l. 7½; 40l. to 60l. 10; 60l. to 80l. 12½; 80l. to 100l. 15; 100l. & upwards 20 Small Consumers, 10s. per meter cub. feet, and 5 per cent. off from 10l. to 25l.	8s. 6d. per ton. 3 sorts used average. Black 8s. 6d. Low moor 8s. 10d. Catherine slack 8s.	8,000	13 cwt.	12s. per ton.	Coke.	5½ cwt.	230	Batswings.	2 12 0	Company light, repair, &c.
Leeds, 1834.	8s. per meter cubic feet. Discounts 2½ } per cent. 15l.; 5 } on half 30l.; 7½ } yearly 50l.; 10 } payments 100l.	8s. per ton average. 2-3ds com'on 7s. 1-3d cannel 10s.	6,500	12 cwt.	7s. 6d. per ton.	Ditto.	3½ cwt.	517	Ditto.	2 12 0	Consumers, except extinguishing, for which Comp'y pay 5s. 6d. per lamp.
Sheffield, 1834.	8s. per meter cubic feet. Disc'ts same as Leeds.	7s. 9d. per ton average. 3 sorts used, 1, 2-10ths can'el, at 15s.; 2, 6-10ths deep pit, 7s.; 3, 1-10th silkstone, 10s.	8,000	10 cwt. of saleable coke.	10s. per ton.	Ditto.	3½ cwt.	600	Ditto.	2 10 0	Company provide lamps, clean, repair, put out, &c.
Leicester, 1837.	7s. 6d. per meter cub. ft. Disc'ts on half-yearly rental, not exceeding 10l., 5 per cent. 10l. 20l. 7½; 20l. 30l. 10; 30l. 40l. 12½; 40l. 50l. 15; 50l. 60l. 20; 60l. & upwards 25	12s. 6d. Average. Derbyshire soft coal.	7,500	4 quarters	10s. 3d. or 2s. 6d. per qr.	Coke, tar, &c.	About 1-3d of coke.	414	Ditto.	2 10 0	Company light, put out, and clean.
Derby, 1834.	10s. per meter cub. feet. Discounts 5 to 25 per cent.	Same coal used as at Leicester.	7,000	Ditto.	Ditto.	Coke.	Ditto.	210	Ditto.	2 2 0 / 2 7 0	Consumers light, put out, &c.
Nottingham, 1834.	8s. per meter cubic feet. Discounts as above.	Ditto.	7,000	Ditto.	Ditto.	Ditto.	Ditto.	200	Ditto.	3 3 0	Consumers light, clean, repair, &c.
London, 1834.	10s. per meter cub. feet. No discounts.	17s. average. Newcastle.	8,800	36 bush.	12s. per chaldron.	Ditto.	13 bush.	26,980	Ditto.	4 6 0	Company light, clean, put out, but not repair.
Ditto, 1837.	Ditto.	Ditto.	8,800	Ditto.	Ditto.	Ditto.	Ditto.	30,400	Ditto.	4 8 0	Ditto.

being a Synopsis of the proceedings of the undermentioned principal Gas-Light Establishments Experiments between the Years 1834 and 1837. By Joseph Hedley, Esq.

f Hours, be burnt n Year.	Gas consumed in each Lamp per Hour.	Rate per Meter Cubic Feet received for Ditto.	Amount deducted for cleaning, lining, ext-ing lamps, provid'g Lamp Post, &c.	Per Centage of Loss of Gas made.	Greatest Quantity of Gas delivered in One Night.	Duration of Charges.	Method of Purification.	Number of Gas Holders.	Specific Gravity of the Gas.	Distance of Candle from Shadow.	Gas equal to Candles. Gas burnt in a single Jet Four Inches high.	Gas consumed per Hour with a Four Inch Flame.	Gas flame reduced to Candle burnt per Hour.	Height of Gas Flame equal to Light from Candle.
	s. d.	*s. d.*	*s. d.*		Cubic Feet.					*Inch.*	*Candles*	*Cu.ft.*	*Cu.ft.*	*Inch.*
ghts, or hours, 9 in omit-l nights holos.	5 feet per hour.	30 10 / 40 18	18 0	Receives net about 6s. 8d. per meter cubic feet.	40 millions in the year.	6 hours.	Dry lime.	4, and 3 in the town, and large new gas station.	·453	70	1,329	1·29	·6	2½
ghts, or hours.	Ditto.	1 3½	18 0	Receives net about 6s. 6d. per meter cubic feet.	36 millions in the year.	Ditto.	Ditto.	6, and 5 in the town 7 miles off.	·455	72	1,307	1·22	·6	2½
onths, sing ½ its for eenh.	4 feet per hour.	3 0	12 0	Could not say.	30,000. Total for year about 16 millions.	6 hours.	Ditto.	3 gas holders.	Not taken	70	304	Not taken	·6	2½
onths, 4 s omit-taneous ights— hours.	Ditto.	3 6	12 6	Ditto.	55,000. Total for year about 11 millions.	Ditto.	Ditto.	4 gas holders.	·530	64	2,441	·35	·55	2 1-5
hours.	1 foot. 2 feet, per hour.	6 6 / 5 6	nothing	About 15 to 17½ per cent receive about 7s. 4d. per meter cubic feet, public and private. Nearly all by meter.	203,000. Total for year 100 millions.	6 hours.	Wet lime.	10 gas holders, and 3 in the town.	·534	66	2,296	·325	·475	2½
hours.	5 feet per hour.	4 4	12 0	Could not learn in the absence of the manager.	300,000. Total for year 72 millions.	6 hours, large retorts, holding 6 cwt. each.	Wet and dry lime, principally dry.	5 gas holders in all, 4 in the town, 1000 yards off the works.	·562	75	1,777	1·1	·75	2 1-5
similar hours.	results, 3½ feet per hour.	which 5 6	see. nothing	Nearly all by meter.	Not sufficiently long at work.	4 hours.	Wet lime.	2 large gas holders.	·530	55	3,306	·9	·45	3
onths, sing 7 . 3600 3 to 4 s in the ing.	5 feet per hour.	2 1	12 6	Receive 3s. per meter cubic feet, less 5½ per cent.	42,500. Total for year 8,619,000.	3 hours.	Dry lime.	4 gas holders.	·450	78	1,645	·12	·9	3
hours.	4 feet per hour.	5 2	8 10	Receive for public and private 6s. 8d. per meter cubic feet. Public 5s, private 7s; meters used 5 to 1 for private rental.	176,000. Total for year 31 millions.	6 hours.	Ditto.	5 gas holders.	·530	67	2,296	·355	·51	2½
hours.	Ditto.	3 2½	12 0	Receive for public and private 6s. 5s. per meter cubic feet. Public 6s. 1d., private 5s. 9d. Few meters used.	230,000. Total for year 40 millions.	Ditto.	Ditto.	4 gas holders, and 2 more erecting.	·456	74	1,885	1·04	·725	2½
August h to umber nting its for r, 2000 rs.	5 feet per hour.	3 4½	7 0	Not sufficiently long, at 7s. 6d.	Total for year 18 millions.	Ditto.	Ditto.	3 gas holders, and 1 erecting.	·526	74	1,826	1·1	·75	2½
hours, August lay.	Ditto.	4 0 nearly	—	Lose about 17½ per cent.	Ditto.	Ditto.	Wet lime.	4 gas holders.	·440	82	1,453	1·2	·225	3
a year, hours.	Ditto.	3 0 nearly	—	Could not learn.	Ditto.	Ditto.	Ditto.	—	·524	90	1,334	1·2	1·175	3
hours, l year.	4 feet per hour.	4 0	12 0	Receive for public and private lights 7s. public, 6s. private, &c. few meters used.	Total for year 1000 millions. Longest night 4,910,000.	Ditto.	Ditto.	130 gas holders.	·412	80	1,563	1·13	·64	2½
tie.	Ditto.	4 0	12 0	Ditto.	Total for year 1400 millions. Longest night 7,130,000.	Ditto.	Ditto.	175 gas holders.	·412	80	1,562	1·13	·64	2½

A Table showing the rate per Thousand Cubic feet received for any Burner consuming from ¼ a Cubic foot to 10 Cubic feet per hour, at any given price per annum, and to the times below stated. By Joseph Hedley, Esq.

Time of Burning per annum.	No. of hours*	Single Jets.				2 Jets.			3 Jets.			Small Argand.			Large Argand.			Fancy and extravagant Burners.		
		Cu. ft. ¼	Cu. ft. ½	Cu. ft. ¾	Cu. ft. 1	Cu. ft. 1¼	Cu. ft. 1½	Cu. ft. 1¾	Cu. ft. 2	Cu. ft. 2¼	Cu. ft. 3	Cu. ft. 3½	Cu. ft. 4	Cu. ft. 4½	Cu. ft. 5	Cu. ft. 6	Cu. ft. 7	Cu. ft. 8	Cu. ft. 9	Cu. ft. 10
From Dusk to 8 o'clock	781	2·50	1·706	·98	1·020	·853	·731	·64	·5199	·4929	·3058	·3201	·2846	·2561	·2134	·1890	·16	·1493	·128
ditto and Sundays	902	2·216	1·478	1·208	·887	·739	·633	·554	·4434	·3695	·3168	·2771	·2404	·2217	·1848	·1564	·1383	·1232	·1108
ditto and from 6 o'clock mornings	1050	1·904	1·27	·952	·762	·635	·544	·476	·391	·3174	·272	·2381	·2110	·1905	·1557	·136	·119	·1058	·0952
ditto and Sundays and from ditto	1172	1·706	1·138	·853	·682	·569	·487	·467	·3412	·2844	·2438	·2133	·1896	·1706	·1422	·1219	·1067	·0948	·0853
9 o'clock	1054	1·896	1·204	·948	·759	·632	·542	·474	·3591	·3162	·272	·2371	·2108	·1807	·1581	·1355	·1185	·1054	·0948
ditto and Sundays	1221	1·638	1·092	·819	·675	·546	·463	·409	·3376	·273	·234	·2047	·182	·1638	·1365	·117	·1024	·091	·0819
ditto and from 6 o'clock mornings	1393	1·510	1·005	·755	·604	·503	·431	·376	·3092	·2519	·2159	·1889	·1678	·1511	·1259	·1079	·0945	·0839	·0735
ditto and Sundays and from ditto	1490	1·342	·894	·671	·536	·447	·383	·335	·2984	·2236	·1918	·1675	·1492	·1312	·1118	·0959	·0839	·0746	·0671
10 o'clock	1367	1·462	·974	·731	·585	·487	·418	·366	·2996	·2436	·209	·1899	·1626	·1463	·1219	·1045	·0914	·0813	·0731
ditto and Sundays	1588	1·26	·84	·63	·504	·42	·36	·315	·2592	·2101	·1502	·1570	·14	·1261	·1051	·0901	·0789	·07	·0630
ditto and from 6 o'clock mornings	1630	1·222	·814	·611	·489	·407	·349	·305	·2444	·2037	·1746	·1598	·1358	·1222	·1019	·0673	·0704	·0679	·0611
ditto and Sundays and from ditto	1855	1·078	·718	·539	·431	·359	·308	·269	·2150	·1796	·154	·1347	·1196	·1078	·0698	·077	·0674	·0599	·0539
11 o'clock	1680	1·19	·794	·595	·476	·397	·34	·297	·238	·1984	·17	·1488	·133	·119	·0992	·085	·0744	·0665	·0595
ditto and Sundays	1951	1·024	·682	·512	·409	·341	·293	·256	·2048	·1707	·1466	·1281	·1138	·1024	·0854	·0733	·064	·0569	·0512
ditto and from 6 o'clock mornings	1949	1·026	·684	·513	·41	·342	·294	·256	·2052	·171	·1466	·1282	·114	·1026	·0855	·0733	·0641	·057	·0513
ditto and Sundays and from ditto	2220	1·	·6	·45	·36	·3	·257	·225	·1802	·1501	·1286	·1126	·1	·0901	·0751	·0643	·0563	·05	·045
12 o'clock	1993	1·	·668	·502	·4	·334	·257	·251	·2008	·1672	·1434	·1254	·1114	·1003	·0836	·0717	·0627	·0557	·0502
ditto and Sundays	2316	·863	·574	·433	·345	·287	·247	·215	·1728	·1439	·1236	·1079	·0958	·0863	·0719	·0616	·0539	·0479	·0432
ditto and from 6 o'clock mornings	2962	·684	·59	·442	·353	·295	·253	·221	·1766	·1476	·1274	·1103	·0992	·0884	·0737	·0637	·0552	·0491	·0449
ditto and Sundays and from ditto	3563	·772	·514	·387	·309	·257	·221	·193	·1546	·1289	·1104	·0967	·0858	·0772	·0643	·0552	·0483	·0429	·0387
1 o'clock	2306	·866	·578	·434	·347	·289	·247	·217	·1731	·1443	·1238	·1086	·0963	·0867	·0723	·0619	·0542	·0483	·0434
ditto and Sundays	2691	·740	·499	·373	·298	·249	·213	·186	·1492	·1243	·1066	·0932	·0828	·0746	·0621	·0533	·0466	·0414	·0373
ditto and from 6 o'clock mornings	2575	·776	·518	·388	·31	·259	·222	·194	·1559	·1294	·104	·0971	·0862	·0776	·0647	·0555	·0485	·0431	·0388
ditto and Sundays and from ditto	2950	·678	·452	·339	·271	·228	·193	·169	·1350	·1130	·111	·0847	·0754	·0678	·0563	·0484	·0424	·0377	·0339
All night	4327	·462	·308	·231	·185	·154	·132	·115	·0924	·077	·066	·0578	·0515	·0462	·0385	·033	·0289	·0257	·0231

To use the Table.—Select the hour to which it is agreed the gas is in to burn,—9, 10, 11 o'clock, Sundays, &c., as the case may be, and the description of the burner.—Multiply the decimal number opposite to it by the amount in shillings agreed to be paid per annum, and the product will be the sum received per m. cubic feet for the gas.

Example.—Suppose a small argand, which should burn 3½ feet per hour, is agreed for till 9 o'clock at 2l. per annum. Look along the line of 9 o'clock till you arrive at the column of 3½ feet per hour, and you find the number, 271. Multiply this number by 40s. and the result gives 10s. 10d. per m. cubic feet. But suppose instead of keeping to 9 o'clock the party burns till 1 o'clock, Sundays and mornings, and by enlarging the holes or height of flame consumes 5 cubic feet of gas per hour; then you have the number, ·0424, which multiplied by 40s. still the price paid, gives 1s. 8d. per m. cubic feet only, and so on for any greater or lesser variation of the agreement.

* The "number of hours" includes ¼ of an hour allowed for shutting shops, and 1 hour's extra burning on Saturday nights.

For lighting London and its suburbs with gas, there are—

18 public gas works.
12   do.   companies.
2,800,000*l.* capital employed in works, pipes, tanks, gas-holders, apparatus.
450,000*l.* yearly revenue derived.
180,000 tons of coals used in the year for making gas.
1,460,000,000 cubic feet of gas made in the year.
134,300 private burners supplied to about 40,000 consumers.
30,400 public or street do.   N. B. about 2650 of these are in the *city* of London.
380 lamplighters employed.
176 gas-holders; several of them double ones, capable of storing 5,500,000 cubic feet.
890 tons of coals used in the retorts on the shortest day, in 24 hours.
7,120,000 cubic feet of gas used in longest night, say 24th December.

About 2500 persons are employed in the metropolis alone, in this branch of manufacture.

Between 1822 and 1827 the quantity nearly doubled itself, and that in 5 years.

Between 1827 and 1837 it doubled itself again.

Mr. Kirkham, engineer, obtained a patent, in June, 1837, for an improved mode of removing the carbonaceous incrustation from the internal surfaces of gas retorts. He employs a jet or jets of heated atmospheric air, or other gases containing oxygen, which he impels with force into the interior of such retorts as have become incrusted in consequence of the decomposition of the coal. The retort is to be kept thoroughly red hot during the application of the proposed jets. An iron pipe, constructed with several flexible joints, leading from a blowing machine, is bent in such a way as to allow its nozzle end to be introduced within the retort, and directed to any point of its surface.

I should suppose that air, even at common temperatures, applied to a retort ignited to the pitch of making gas, would burn away the incrustations; but hot air will, no doubt, be more powerful.

GAS-HOLDER; a vessel for containing and preserving gas, of which various forms are described by chemical writers.

GASOMETER means properly a measurer of gas, though it is employed often to denote a recipient of gas of any kind. See the article GAS-LIGHT.

GAUZE WIRE CLOTH is a textile fabric, either plane or tweeled, made of brass, iron, or copper wire, of very various degrees of fineness and openness of texture. Its chief uses are for sieves, and safety-lamps.

GAY-LUSSITE is a white mineral of a vitreous fracture, which crystallizes in oblique rhomboidal prisms; specific gravity from 1·93 to 1·95; scratches gypsum, but is scratched by calcspar; affords water by calcination; it consists of carbonic acid, 28·66; soda, 20·44; lime, 17·70; water, 32·20; clay, 1·00. It is, in fact, by my analysis, a hydrated soda-carbonate of lime in atomic proportions. This mineral occurs abundantly in insulated crystals, disseminated through the bed of clay which covers the *urao*, or native sesquicarbonate of soda, at Lagunilla in Colombia.

GELATINE (Eng. and Fr.; *Gallert, Leim*, Germ.) is an animal product which is never found in the humors, but it may be obtained by boiling with water the soft and solid parts; as the muscles, the skin, the cartilages, bones, ligaments, tendons, and membranes. Isinglass consists almost entirely of gelatine. This substance is very soluble in boiling water; the solution forms a tremulous mass of jelly when it cools. Cold water has little action upon gelatine. Alcohol and tanpin (tannic acid, see GALL-NUTS) precipitate gelatine from its solution; the former by abstracting the water, the latter by combining with the substance itself into an insoluble compound, of the nature of leather. No other acid, except the tannic, and no alkali possesses the property of precipitating gelatine. But chlorine and certain salts render its solution more or less turbid; as the nitrate and bi-chloride of mercury, the proto-chloride of tin, and a few others. Sulphuric acid converts a solution of gelatine at a boiling heat into sugar. See LIGNEOUS FIBRE. Gelatine consists of carbon, 47·88; hydrogen, 7·91; oxygen, 27·21. See GLUE and ISINGLASS.

GEMS are precious stones, which, by their color, limpidity, lustre, brilliant polish, purity, and rarity, are sought after as objects of dress and decoration. They form the principal part of the crown jewels of kings, not only from their beauty, but because they are supposed to comprise the greatest value in the smallest bulk; for a diamond, no larger than a nut or an acorn, may be the representative sign of the territorial value of a whole country, the equivalent in commercial exchange of a hundred fortunes, acquired by severe toils and privations.

Among these beautiful minerals mankind have agreed in forming a select class, to which the title of *gems* or *jewels* has been appropriated; while the term *precious stone* is more particularly given to substances which often occur under a more considerable volume than *fine stones* ever do.

Diamonds, sapphires, emeralds, rubies, topazes, hyacinths, and chrysoberyls, are reckoned the most valuable *gems*.

Cyrstalline quartz, pellucid, opalescent, or of various hues, amethyst, lapis lazuli, malachite, jasper, agate, &c., are ranked in the much more numerous and inferior class of ornamental stones. These distinctions are not founded upon any strict philosophical principle, but are regulated by a conventional agreement, not very well defined; for it is impossible to subject these creatures of fashion and taste to the rigid subdivisions of science. We have only to consider the value currently attached to them, and take care not to confound two stones of the same color, but which may be very differently prized by the *virtuoso*.

Since it usually happens that the true gems are in a cut and polished state, or even set in gold or silver, we are thereby unable to apply to them the criteria of mineralogical and chemical science. The cutting of the stone has removed or masked its crystalline character, and circumstances rarely permit the phenomena of double or single refraction to be observed; while the test by the blowpipe is inadmissible. Hence the only scientific resources that remain are the trial by electricity, which is often inconclusive; the degree of hardness, a criterion requiring great experience in the person who employs it; and, lastly, the proof by specific gravity, unquestionably one of the surest means of distinguishing the really fine gems from ornamental stones of similar color. This proof can be applied only to a stone that is not set; but the richer gems are usually dismounted, when offered for sale.

This character of specific gravity may be applied by any person of common intelligence, with the aid of a small hydrostatic balance. If, for example, a stone of a fine crimson-red color be offered for sale, as an oriental ruby; the purchaser must ascertain if it be not a Siberian tourmaline, or ruby spinel. Supposing its weight in air to be 100 grains, if he finds it reduced to 69 grains, when weighed in water, he concludes that its bulk is equal to that of 31 grains of water, which is its loss of weight. Now, a real sapphire which weighs 100 grains in air, would have weighed 76·6 in water; a spinel ruby of 100 grains would have weighed 72·2 in water, and a Siberian tourmaline of 100 grains would have weighed only 69 grains in water. The quality of the stone in question is, therefore, determined beyond all dispute, and the purchaser may be thus protected from fraud.

The *sard* of the English jewellers (*Sardoine*, French) is a stone of the nature of agate, having an orange color more or less deep, and passing by insensible shades into yellow, reddish, and brown; whence it has been agreed to unite under this denomination all the agates whose color verges upon brown. It should be remarked, however, that the sard presents, in its interior and in the middle of its ground, concentric zones, or small nebulosities, which are not to be seen in the red cornelian, properly so called. The ancients certainly knew our sard, since they have left us a great many of them engraved, but they seem to have associated under the title *sarda* both the sardoine of the French, and our cornelians and calcedonies. Pliny says that the *sarda* came from the neighborhood of a city of that name in Lydia, and from the environs of Babylon. Among the engraved sards which exist in the collection of antiques in the Bibliothèque Royale of Paris, there is an Apollo remarkable for its fine color and great size. When the stone forms a part of the agate-onyx, it is called sardonyx. For further details upon Gems, and the art of cutting and engraving them, See LAPIDARY.

GEOGNOSY, means a knowledge of the structure of the earth; GEOLOGY, a description of the same. The discussion of this subject does not come within the province of this Dictionary.

GERMAN SILVER. See the latter end of the article COPPER.

GERMINATION (Eng. and Fr.; *Das Keimen*, Germ.) is the first sprouting of a seed after it is sown, or when, after steeping, it is spread upon the malt floor. See BEER.

GIG MACHINES are rotatory drums, mounted with thistles or wire teeth for teazling cloth. See WOOLLEN MANUFACTURE.

GILDING (*Dorure*, Fr.; *Vergoldung*, Germ.) is the art of coating surfaces with a thin film of gold. For a full discussion of this subject, See GOLD. Mr. Elkington, gilt toy maker, obtained a patent in June, 1836, for gilding copper, brass, &c., by means of potash or soda combined with carbonic acid, and with a solution of gold. Dissolve, says he, 5 oz. troy of fine gold in 52 oz. avoirdupois of nitro-muriatic acid of the following proportions: viz. 21 oz. of pure nitric acid, of spec. grav. 1·45, 17 oz. of pure muriatic acid, of spec. grav. 1·15; with 14 oz. of distilled water.

The gold being put into the mixture of acids and water, they are to be heated in a glass or other convenient vessel till the gold is dissolved; and it is usual to continue the application of heat after this is effected, until a reddish or yellowish vapor ceases to rise.

The clear liquid is to be carefully poured off from any sediment which generally appears and results from a small portion of silver, which is generally found in alloy with gold. The clear liquid is to be placed in a suitable vessel of stone, pottery ware is preferred. Add to the solution of gold 4 gallons of distilled water, and 20 pounds of bicar-

bonate of potash of the best quality; let the whole boil moderately for two hours, the mixture will then be ready for use.

The articles to be gilded having been first perfectly cleaned from scale or grease, they are to be suspended on wires, conveniently for a workman to dip them in the liquid, which is kept boiling. The time required for gilding any particular article will depend on circumstances, partly on the quantity of gold remaining in the liquid, and partly on the size and weight of the article; but a little practice will readily give sufficient guidance to the workman.

Supposing the articles desired to be gilded be brass or copper buttons, or small articles for gilt toys, or ornaments of dress, such as ear-rings or bracelets, a considerable number of which may be strung on a hoop, or bended piece of copper or brass wire, and dipped into the vessel containing the boiling liquid above described, and moved therein, the requisite gilding will be generally obtained in from a few seconds to a minute; this is when the liquid is in the condition above described, and depending on the quality of the gilding desired; but if the liquid has been used some time, the quantity of gold will be lessened, which will vary the time of operating to produce a given effect, or the color required, all which will quickly be observed by the workman; and by noting the appearance of the articles from time to time, he will know when the desired object is obtained, though it is desirable to avoid as much as possible taking the articles out of the liquid.

When the operation is completed, the workman perfectly washes the articles so gilded with clean water; they may then be submitted to the usual process of coloring.

If the articles be cast figures of animals, or otherwise of considerable weight, compared with the articles above mentioned, the time required to perform the process will be greater.

In case it is desired to produce what is called a dead appearance, it may be performed by several processes: the one usually employed is to dead the articles in the process of cleaning, as practised by brass-founders and other trades; it is produced by an acid, prepared for that purpose, sold by the makers under the term " deading aquafortis," which is well understood.

It may also be produced by a weak solution of nitrate of mercury, applied to the articles previous to the gilding process, as is practised in the process of gilding with mercury, previous to spreading the amalgam, but generally a much weaker solution; or the articles having been gilded may be dipped in a solution of nitrate of mercury, and submitted to heat to expel the same, as is practised in the usual process of gilding.

It is desirable to remark, that much of the beauty of the result depends on the well cleaning of the articles, and it is better to clean them by the ordinary processes, and at once pass them into the liquid to be gilded. See GOLD, towards the end.

GIN, or *Geneva*, from *Genverre* (juniper), is a kind of ardent spirits manufactured in Holland, and hence called Hollands gin in this country, to distinguish it from British gin. The materials employed in the distilleries of Schiedam, are two parts of unmalted rye from Riga, weighing about 54 lbs. per bushel, and one part of malted bigg, weighing about 37 lbs. per bushel. The mash tun, which serves also as the fermenting tun, has a capacity of nearly 700 gallons, being about five feet in diameter at the mouth, rather narrower at the bottom, and 4½ feet deep; the stirring apparatus is an oblong rectangular iron grid, made fast to the end of a wooden pole. About a barrel, = 36 gallons of water, at a temperature of from 162° to 168° (the former heat being best for the most highly dried rye), are put into the mash tun for every 1½ cwt. of meal, after which the malt is introduced and stirred, and lastly the rye is added. Powerful agitation is given to the magma till it becomes quite uniform; a process which a vigorous workman piques himself upon executing in the course of a few minutes. The mouth of the tun is immediately covered over with canvass, and further secured by a close wooden lid, to confine the heat; it is left in this state for two hours. The contents being then stirred up once more, the *transparent* spent wash of a preceding mashing is first added, and next as much cold water as will reduce the temperature of the whole to about 85° F. The best Flanders yeast, which had been brought, for the sake of carriage, to a doughy consistence by pressure, is now introduced to the amount of one pound for every 100 gallons of the mashed materials.

The gravity of the fresh wort is usually from 33 to 38 lbs. per Dicas' hydrometer; and the fermentation is carried on from 48 to 60 hours, at the end of which time the attenuation is from 7 to 4 lbs., that is, the specific gravity of the supernatant wash is from 1·007 to 1·004.

The distillers are induced by the scarcity of beer-barm in Holland, to skim off a quantity of the yeast from the fermenting tuns, and to sell it to the bakers, whereby they obstruct materially the production of spirit, though they probably improve its quality, by preventing its impregnation with yeasty particles; an unpleasant result which seldom fails to take place in the whiskey distilleries of the United Kingdom.

On the third day after the fermenting tun is set, the wash containing the grains is transferred to the still, and converted into low wines. To every 100 gallons of this liquor, two pounds of juniper berries, from 3 to 5 years old, being added along with about one quarter of a pound of salt, the whole are put into the low wine still, and the fine Hollands spirit is drawn off by a gentle and well-regulated heat, till the magma becomes exhausted; the first and the last products being mixed together; whereby a spirit, 2 to 3 per cent. above our hydrometer proof, is obtained, possessing the peculiar fine aroma of gin. The quantity of spirit varies from 18 to 21 gallons per quarter of grain; this large product being partly due to the employment of the spent wash of the preceding fermentation; an addition which contributes at the same time to improve the flavor.

For the above instructive details of the manufacture of genuine Hollands, I am indebted to Robert More, Esq., formerly of Underwood, distiller, who, after studying the art at Schiedam, tried to introduce that spirit into general consumption in this country, but found the palates of our gin-drinkers too much corrupted to relish so pure a beverage.

GINNING, is the name of the operation by which the filaments of cotton are separated from the seeds. See COTTON MANUFACTURE.

GLANCE COAL, or anthracite, of which there are two varieties, the *slaty* and the *conchoidal*. See ANTHRACITE.

GLASS (*Verre*, Fr.; *Glas*, Germ.) is a transparent solid formed by the fusion of silicious and alkaline matter. It was known to the Phenicians, and constituted for a long time an exclusive manufacture of that people, in consequence of its ingredients, natron, sand, and fuel, abounding upon their coasts. It is probable that the more ancient Egyptians were unacquainted with glass, for we find no mention of it in the writings of Moses. But according to Pliny and Strabo, the glass works of Sidon and Alexandria were famous in their times, and produced beautiful articles; which were cut, engraved, gilt, and stained of the most brilliant colors, in imitation of precious stones. The Romans employed glass for various purposes; and have left specimens in Herculaneum of window-glass, which must have been blown by methods analogous to the modern. The Phenician processes seem to have been learned by the Crusaders, and transferred to Venice in the 13th century, where they were long held secret, and formed a lucrative commercial monopoly. Soon after the middle of the 17th century, Colbert enriched France with the blown mirror glass manufacture.

Chance undoubtedly had a principal share in the invention of this curious fabrication, but there were circumstances in the most ancient arts likely to lead to it; such as the fusing and vitrifying heats required for the formation of pottery, and for the extraction of metals from their ores. Pliny ascribes the origin of glass to the following accident. A merchant-ship laden with natron being driven upon the coast at the mouth of the river Belus, in tempestuous weather, the crew were compelled to cook their victuals ashore, and having placed lumps of the natron upon the sand, as supports to the kettles, found to their surprise masses of transparent stone among the cinders. The sand of this small stream of Galilee, which runs from the foot of Mount Carmel, was in consequence supposed to possess a peculiar virtue for making glass, and continued for ages to be sought after and exported to distant countries for this purpose.

Agricola, the oldest author who has written technically upon glass, describes furnaces and processes closely resembling those employed at the present day. Neri, Kunckel, Henckel, Pott, Achard, and some other chemists, have since then composed treatises upon the subject; but Neri, Bosc, Antic, Loysel, and Allut, in the Encyclopedie Methodique, are the best of the elder authorities.

The window-glass manufacture was first begun in England in 1557, in Crutched Friars, London; and fine articles of flint-glass were soon afterwards made in the Savoy House, Strand. In 1635 the art received a great improvement from Sir Robert Mansell, by the use of coal fuel instead of wood. The first sheets of blown glass for looking glasses and coach windows were made in 1673 at Lambeth, by Venetian artisans employed under the patronage of the Duke of Buckingham.

The casting of mirror-plates was commenced in France about the year 1688, by Abraham Thevart; an invention which gave rise soon afterwards to the establishment of the celebrated works of St. Gobin, which continued for nearly a century the sole place where this highly prized object of luxury was well made. In excellence and cheapness, the French mirror-plate has been, however, for some time rivalled by the English.

The analysis of modern chemists, which will be detailed in the course of this article, and the light thrown upon the manufacture of glass in general by the accurate means now possessed of purifying its several ingredients, would have brought the art to the highest state of perfection in this country, but for the vexatious interference and obstructions of our excise laws.

The researches of Berzelius having removed all doubts concerning the acid character of silica, the general composition of glass presents now no difficulty of conception. This substance consists of one or more salts, which are silicates with bases of potash

soda, lime, oxyde of iron, alumina, or oxyde of lead; in any of which compounds we can substitute one of these bases for another, provided that one alkaline base be left. Silica in its turn may be replaced by the boracic acid, without causing the glass to lose its principal characters.

Under the title glass are therefore comprehended various substances fusible at a high temperature, solid at ordinary temperatures, brilliant, generally more or less transparent, and always brittle. The following chemical distribution of glasses has been proposed.

1. Soluble glass; a simple silicate of potash or soda; or of both these alkalis.
2. Bohemian or crown glass; silicate of potash and lime.
3. Common window and mirror glass; silicate of soda and lime; sometimes also of potash.
4. Bottle glass; silicate of soda, lime, alumina, and iron.
5. Ordinary crystal glass; silicate of potash and lead.
6. Flint glass; silicate of potash and lead; richer in lead than the preceding.
7. Strass; silicate of potash and lead; still richer in lead.
8. Enamel; silicate and stannate or antimoniate of potash or soda and lead.

The glasses which contain several bases are liable to suffer different changes when they are melted or cooled slowly. The silica is divided among these bases, forming new compounds in definite proportions, which by crystallizing, separate from each other, so that the general mixture of the ingredients which constituted glass is destroyed. It becomes then very hard, fibrous, opaque, much less fusible, a better conductor of electricity and of heat; forming what Reaumur styled *devitrified* glass; and what is called after him, Reaumur's porcelain.

This altered glass can always be produced in a more or less perfect state, by melting the glass and allowing it to cool very slowly; or merely by heating it to the softening pitch, and keeping it at this heat for some time. The process succeeds best with the most complex vitreous compounds, such as bottle glass; next with ordinary window glass; and lastly with glass of potash and lead.

This property ought to be kept constantly in view in manufacturing glass. It shows why in making bottles we should fashion them as quickly as possible with the aid of a mould, and reheat them as seldom as may be absolutely necessary. If it be often heated and cooled, the glass loses its ductility, becomes refractory, and exhibits a multitude of stony granulations throughout its substance. When coarse glass is worked at the enameller's lamp, it is apt to change its nature in the same way, if the workman be not quick and expert at his business.

From these facts we perceive the importance of making a careful choice of the glass intended to be worked in considerable masses, such as the large object glasses of telescopes; as their annealing requires a very slow process of refrigeration, which is apt to cause devitrified specks and clouds. For such purposes, therefore, no other species of glass is well adapted except that with basis of potash and lead; or that with basis of potash and lime. These two form the best flint glass and crown glass; and they should be exclusively employed for the construction of the object glasses of achromatic telescopes.

GLASS-MAKING, *general principles of.* Glass may be defined in technical phraseology, to be a transparent homogeneous compound formed by the fusion of silica with oxydes of the alkaline, earthy, or common metals. It is usually colorless, and then resembles rock crystal, but is occasionally stained by accident or design with colored metallic oxydes. At common temperatures it is hard and brittle, in thick pieces; in thin plates or threads, flexible and elastic; sonorous when struck; fracture conchoidal, and of that peculiar lustre called vitreous; at a red heat, becoming soft, ductile, and plastic. Besides glass properly so called, other bodies are capable of entering into vitreous fusion, as phosphoric acid, boracic acid, arsenic acid, as also certain metallic oxydes, as of lead and antimony, and several chlorides; some of which are denominated glasses. Impure and opaque vitriform masses are called slags; such are the productions of blast iron furnaces and many metallurgic operations.

Silica, formerly styled the earth of flints, which constitutes the basis of all commercial glass, is infusible by itself in the strongest fire of our furnaces; but its vitreous fusion is easily effected by a competent addition of potash or soda, either alone or mixed with lime or litharge. The silica, which may be regarded as belonging to the class of acids, combines at the heat of fusion with these bases, into saline compounds; and hence glass may be viewed as a silicate of certain oxydes, in which the acid and the bases exist in equivalent proportions. Were these proportions, or the quantities of the bases which silica requires for its saturation at the melting point, exactly ascertained, we might readily determine beforehand the best proportions of materials for the glass manufacture. But as this is far from being the case, and as it is, moreover, not improbable that the capacity of saturation of the silica varies with the temperature, and that the properties of glass also vary with the bases, we must, in the present state of our knowledge, regulate the proportions rather by practice than by theory, though the latter may throw an

indirect light upon the subject. For example, a good colorless glass has been found by analysis to consist of 72 parts of silica, 13 parts of potash, and 10 parts of lime, in 95 parts. If we reduce these numbers to the equivalent ratios, we shall have the following results; taking the atomic weights as given by Berzelius.

1 atom potash =	590	14.67	
1	lime	356	8.84
3	silica	1722	42.79 } 71.49
2	silica	1155	28.70
		2823	95.00

This glass would therefore have been probably better compounded with the just atomic proportions, to which it nearly approaches, viz. 71.49 silica, 14.67 potash, and 8.84 lime, instead of those given above as its actual constituents.

The proportions in which silica unites with the alkaline and other oxydes are modified by the temperature as above stated; the lower the heat, the less silica will enter into the glass, and the more of the base will in general be required. If a glass which contains an excess of alkali be exposed to a much higher temperature than that of its formation, a portion of the base will be set free to act upon the materials of the earthen pot, or to be dissipated in fumes, until such a silicate remains as to constitute a permanent glass corresponding to that temperature. Hence the same mixture of vitrifiable materials will yield very different results, according to the heats in which it is fused and worked in the glass-house; and therefore the composition should always be referrible to the going of the furnace. When a species of glass which at a high temperature formed a transparent combination with a considerable quantity of lime, is kept for some time in fusion at a lower temperature, a portion of the lime unites with the silica into another combination of a semi-vitreous or even of a stony aspect, so as to spoil the transparency of the glass altogether. There is probably a supersilicate and a sub-silicate formed in such cases; the latter being much the more fusible of the two compounds. The Reamur's porcelain produced by exposing bottle glass to a red heat for 24 hours, is an example of this species of vitreous change, in which new affinities are exercised at a lower temperature. An excess of silica, caused by the volatilization of alkaline matter with too strong firing, will bring on similar appearances.

The specific gravity of glass varies from 2.3 to 3.6. That of least specific gravity consists of merely silica and potash fused together; that with lime is somewhat denser, and with oxyde of lead denser still. Plate glass made from silica, soda, and lime, has a specific gravity which varies from 2.50 to 2.6; crystal or flint glass from 3.0 to 3.6.

The power of glass to resist the action of water, alkalis, acids, air, and light, is in general the greater, the higher the temperature employed in its manufacture, the smaller the proportion of its fluxes, and the more exact the equivalent ratios of its constituents. When glass contains too much alkali, it is partially soluble in water. Most crystal glass is affected by having water boiled in it for a considerable time; but crown glass being poorer in alkali, and containing no lead, resists that action much longer, and is therefore better adapted to chemical operations. The affinity of glass for water, or its hygrometric attraction, is also proportional to the quantity of alkali which it contains. In general also potash glass is more apt to become damp than soda glass, agreeably to the respective hygrometric properties of these two alkalis, and also to the smaller proportion of soda than of potash requisite to form glass.

Air and light operate upon glass probably by their oxydizing property. Bluish or greenish colored glasses become by exposure colorless, in consequence undoubtedly of the peroxydizement of the iron, to whose protoxyde they owe their tint; other glasses become purple red from the peroxydizement of the manganese. The glasses which contain lead, suffer another kind of change in the air, if sulphureted hydrogen be present; the oxyde of lead is converted into a sulphuret, with the effect of rendering the surface of the glass opaque and iridescent. The more lead is in the glass, the quicker does this iridescence supervene. By boiling concentrated sulphuric acid in a glass vessel, or upon glass, we can ascertain its power of resisting ordinary menstrua. Good glass will remain smooth and transparent; bad glass will become rough and dim.

The brittleness of unannealed glass by change of temperature is sometimes very great. I have known a thick vessel to fly by vicissitudes of the atmosphere alone. This defect may be corrected by slowly heating the vessel in salt water or oil to the highest pitch consistent with the nature of these liquids, and letting it cool very slowly. Within the limits of that range of heat, it will, in consequence of this treatment, bear alternations of temperature without cracking as before.

It has been said that glass made from silica and alkalis alone will not resist the action of water, but that the addition of a little lime is necessary for this effect. In general

parts of quartzose sand require 33 parts of dry carbonate of soda for their vitrifica-
and 45 parts of dry carbonate of potash. But to make unchangeable alkaline glass,
cially with potash, a smaller quantity of this than the above should be used, with a
violent heat. A small proportion of lime increases the density, hardness, and lustre
lass; and it aids in decomposing the alkaline sulphates and muriates always present
he pearlash of commerce. From 7 to 20 parts of dry slaked lime have been added
00 of silica, with advantge, it is said, in some German glass manufactories, where
alkaline matter is soda ; for potash does not assimilate well with the calcareous
2.

many glass works on the Continent, sulphate of soda is the form under which alkaline
er is introduced into glass. This salt requires the addition of 8 per cent. of char-
to decompose and dissipate its acid; a result which takes place at a high heat, with-
the addition of any lime. 88 pounds of quartz-sand, 44 pounds of dry glauber salt,
3 pounds of charcoal, properly mixed and fused, afford a limpid, fluent, and workable
s; with the addition of 17 pounds of lime, these materials fuse more readily into a
ie mass. If less carbon be added, the fusion becomes more tedious. The two follow-
ormulæ afford good glauber salt glass.

	1.	2.
Sand - - - - - -	100	60·3
Calcined sulphate of soda - -	50	26·8
Lime - - - - - -	20	10 8
Charcoal - - - - -	2·65	2·1

he first mixture has been proved in the looking-glass manufactory of Neuhaus near
ina, and the second by the experiments of Kirn. The fusion of the first requires
f the second 21 hours. The bluish green tinge which these otherwise beautiful and
iant glasses possess, is not removeable by the ordinary means, such as manganese or
nic, which decolor alkaline glass. When the sulphate of soda and charcoal are used
naller proportions, the glass becomes more colorless. The tinge is no doubt owing
ie sulphur combining with the oxyde of sodium, in some such way as in the pigment
ssmarine.

f a proper addition of galena (the native sulphuret of lead), to glauber salt and quartz
, without charcoal, it is said a tolerably good crystal glass may be formed. The
huric acid of the salt is probably converted by the reaction of the sulphuret of lead
sulphurous acid gas, which is disengaged.

ne atom of sulphuret of lead = 1495·67, is requisite to decompose 3 atoms of sulphate
oda = 2676. It is stated, on good authority, that a good colorless glass may be ob-
ed by using glauber salt without charcoal, as by the following formula.

Quartz-sand - - - -	100 pounds
Calcined glauber salt - -	24
Lime - - - - -	20
Cullet of soda glass - -	12

he melting heat must be continued for 26½ hours. A small quantity of the sand is
rved to be thrown in towards the conclusion of the process, in order to facilitate the
ilsion of air bubbles. The above mixture will bear to be blanched by the addition
anganese and arsenic. The decomposition of the salt is in this case effected by the
, with which the sulphuric acid first combines, is then converted into sulphurous acid,
dissipated. Glass made in this way was found by analysis to consist of 79 parts of
a, 12 lime, and 9·6 soda, without any trace of gypsum or sulphuric acid.

lauber salt is partially volatilized by the heat of the furnace, and acts upon the arch
he oven and the tops of the pots. This is best prevented by introducing at first into
pots the whole of the salt mixed with the charcoal, the lime, and one fourth part of
sand ; fusing this mixture at a moderate heat, and adding gradually afterwards the
ainder of the sand, increasing the temperature at the same time. If we put in the
le ingredients together, as is done with potash glass, the sand and lime soon fall to
bottom, while the salt rises to the surface, and the combination becomes difficult and
qual.

ulphate of potash acts in the same way as sulphate of soda.

Iuriate of soda also, according to Kirn, may be used as a glass flux with advantage.
most suitable proportions are 4 parts of potash, 2 of common salt, and 3 of lime,
eably to the following compositions :—

	1.	2.
Quartz-sand - - - - -	60·0	75·1
Calcined carbonate of potash - -	17·8	19·1
Common salt - - - - -	8·9	9·5
Lime - - - - - -	13·3	14·3

For No. 1, the melting heat must be 10 hours, which turns out a very pure, solid, good glass; for No. 2, 23 hours of the furnace are required. Instead of the potash, glauber salt may be substituted; the proportions being then 19·1 glauber salt, 9·5 muriate of soda, 14·3 lime, 75·1 sand, and 1·3 charcoal.

The oxyde of lead is an essential constituent of the denser glasses, and may be regarded as replacing the lime, so as to form with the quartz-sand a silicate of lead. It assimilates best with purified pearlash, on account of the freedom of this alkali from iron, which is present in most sodas.

Its atomac constitution may be represented as follows :—

				Computation.	Analysis.
Silicic acid - - -	5 atoms	=	2877·	59·19	59·20
Oxyde of Lead - - -	1	=	1394·5	28·68	28·20
Potash - - - -	1	=	590·0	12·13	9·00
Oxydes of iron and manganese.			—	—	1·40
			4861·5	100·00	100·00

The above analysis by Berthier relates to a specimen of the best English crystal glass, perfectly colorless and free from air-bubbles. This kind of glass may however take several different proportions of potash and silica to the oxyde of lead.

The composition of mirror plate, as made on the Continent, is as follows :—
White quartz-sand - - - - - - - - 300 pounds
Dry carbonate of soda - - - - - - - 100
Lime slaked in the air - - - - - - - 43
Cullet, or old glass - - - - - - - 300
The manganese should not exceed one half per cent. of the weight of the soda.

Optical glass requires to be made with very peculiar care. It is of two different kinds; namely, *crown glass* and *flint glass*. The latter contains a considerable proportion of lead, in order to give it an increased dispersive power upon the rays of light, in proportion to its mean refractive power.

Optical crown glass should be perfectly limpid, and have so little color, that a pretty thick piece of it may give no appreciable tinge to the rays of light. It should be exempt from striæ or veins as well as air-bubbles, and have not the slightest degree of milkiness. It should moreover preserve these qualities when worked in considerable quantities. Potash is preferable to soda for making optical crown glass, because the latter alkali is apt to make a glass which devitrifies and becomes opalescent, by long exposure to heat in the annealing process. A simple potash silicate would be free from this defect, but it would be too attractive of moisture, and apt to decompose eventually by the humidity of the atmosphere. It should therefore contain a small quantity of lime, and as little potash as suffices for making a perfect glass at a pretty high temperature. It is probably owing to the high heats used in the English crown glass works, and the moderate quantity of alkali (soda) which is employed, that our crown glass has been found to answer so well for optical purposes.

PRACTICAL DETAILS OF THE MANUFACTURE OF GLASS.

The Venetians were the first in modern times who attained to any degree of excellence in the art of working glass, but the French became eventually so zealous of rivalling them, particularly in the construction of mirrors, that a decree was issued by the court of France, declaring not only that the manufacture of glass should not derogate from the dignity of a nobleman, but that nobles alone should be masters of glass-works. Within the last 30 or forty years, Great Britain has made rapid advances in this important art, and at the present day her pre-eminence in every department hardly admits of dispute.

There are five different species of glass, each requiring a peculiar mode of fabrication, and peculiar materials : 1. The coarsest and simplest form of this manufacture is *bottle* glass. 2. Next to it in cheapness of material may be ranked *broad* or *spread window glass*. An improved article of this kind is now made near Birmingham, under the name of British or German plate. 3. Crown glass comes next, or window glass, formed in large circular plates or discs. This glass is peculiar to Great Britain. 4. Flint glass, crystal glass, or glass of lead. 5. Plate or fine mirror glass.

The materials of every kind of glass are vitrified in pots made of a pure refractory clay ; the best kind of which is a species of shale or slate clay dug out of the coal-formation near Stourbridge. It contains hardly any lime or iron, and consists of silica and alumina in nearly equal proportions. The masses are carefully picked, brushed, and ground under edge iron wheels of considerable weight, and sifted through sieves

having 20 meshes in the square inch. This powder is moistened with water (best hot), and kneaded by the feet or a loam-mill into a uniform smooth paste. A large body of this dough should be made up at a time, and laid by in a damp cellar to ripen. Previously to working it into shapes, it should be mixed with about a fourth of its weight of cement of old pots, ground to powder. This mixture is sufficiently plastic, and being less contractile by heat, forms more solid and durable vessels. Glass-house pots have the figure of a truncated cone, with the narrow end undermost; those for bottle and window-glass being open at top, about 30 inches diameter at bottom, 40 inches at the mouth, and 40 inches deep; but the flint-glass pots are covered in at top with a dome-cap, having a mouth at the side, by which the materials are introduced, and the glass is extracted. Bottle and crown-house pots are from 3 to 4 inches thick; those for flint-houses are an inch thinner, and of proportionally smaller capacity.

The well-mixed and kneaded dough is first worked upon a board into a cake for the bottom; over this the sides are raised, by laying on its edges rolls of clay above each other with much manual labor, and careful condensation. The clay is made into lumps, is equalized, and slapped much in the same way as for making POTTERY. The pots thus fashioned must be dried very prudently, first in the atmospheric temperature, and finally in a stove floor, which usually borrows its heat directly from the glass-house. Before *setting the pots* in the furnace, they are annealed during 4 or 5 days, at a red heat, in a small reverberatory vault, made on purpose. When completely annealed, they are transferred with the utmost expedition into their seat in the fire, by means of powerful tongs supported on the axle of an iron-wheel carriage frame, and terminating in a long lever for raising them and swinging them round. The *pot-setting* is a desperate service, and when unskilfully conducted without due mechanical aids, is the forlorn hope of the glass-founder.—*Quæque ipse miserrima vidi.* The celebrated chemist, Dr. Irvine, caught his last illness by assisting imprudently at this formidable operation. The working breast of the hot furnace must be laid bare so as to open a breach for the extraction of the faulty pot, and the insertion of the fresh one, both in a state of bright incandescence. It is frightful to witness the eyes and fuming visages of the workmen, with the blackening and smoking of their scorched woollen clothes, exposed so long to the direct radiations of the flame. A light mask and sack dress coated with tinfoil, would protect both their faces and persons from any annoyance, at a very cheap rate.

The glass-houses are usually built in the form of a cone, from 60 to 100 feet high, and from 50 to 80 feet in diameter at the base. The furnace is constructed in the centre of the area, above an arched or groined gallery which extends across the whole space, and terminates without the walls, in large folding doors. This cavern must be sufficiently high to allow laborers to wheel out the cinders in their barrows. The middle of the vaulted top is left open in the building, and is covered over with the grate-bars of the furnace.

1. *Bottle glass.*—The bottle-house and its furnace resemble nearly *fig.* 505. The furnace is usually an oblong square chamber, built of large fire-bricks, and arched over with fire-stone, a silicious grit of excellent quality extracted from the coal measures of Newcastle. This furnace stands in the middle of the area; and has its base divided into three compartments. The central space is occupied by the grate-bars; and on either side is the platform or fire-brick *siege* (seat), raised about 12 inches above the level of the ribs upon which the pots rest. Each *siege* is about 3 feet broad.

In the sides of the furnace, semi-circular holes of about a foot diameter are left opposite to, and a little above the top of each pot, called working holes, by which the workmen shovel in the materials, and take out the plastic glass. At each angle of the furnace there is likewise a hole of about the same size, which communicates with the calcining furnace of a cylindrical form, dome-shaped at top. The flame that escapes from the founding or pot-furnace is thus economically brought to reverberate on the raw materials of the bottle glass, so as to dissipate their carbonaceous or volatile impurities, and convert them into a frit. A bottle-house has generally eight other furnaces or fire-arches; of which six are used for annealing the bottles after they are blown, and two for annealing the pots, before setting them in the furnace.

The laws of this country till lately prohibited the use for making common bottles of any fine materials. Nothing but the common river sand, and soap-boilers' waste, was allowed. About 3 parts of waste, consisting of the insoluble residuum of kelp, mixed with lime and a little saline substance, were used for 1 part of sand. This waste was first of all calcined in two of the fire arches or reverberatories reserved for that purpose, called the coarse arches, where it was kept at a red heat, with occasional stirring, from 24 to 30 hours, being the period of a journey or *journée*, in which the materials could be melted and worked into bottles. The roasted soap-waste was then withdrawn, under the name of ashes, from its arch, coarsely ground, and mixed with its proper proportion of sand. This mixture was now put into the fine arch, and calcined during the working journey, which extended to 10 or 12 hours. Whenever the pots were worked out, that frit

was immediately transferred into them in its ignited state, and the founding process proceeded with such despatch that this first charge of materials was completely melted down in 6 hours, so that the pots might admit to be filled up again with the second charge of frit, which was founded in 4 hours more. The heat was briskly continued, and in the course of from 12 to 18 hours, according to the size of the pots, the quality of the fuel, and the draught of the furnace, the vitrification was complete. Before blowing the bottles, however, the glass must be left to settle, and to cool down to the blowing consistency, by shutting the care doors and feeding holes, so as to exclude the air from the fire-grate and the bottom of the hearth. The glass or metal becomes more dense, and by its subsidence throws up the foreign lighter earthy and saline matters in the form of a scum on the surface, which is removed with skimming irons. The furnace is now charged with coal, to enable it to afford a working heat for 4 or 5 hours, at the end of which time more fuel is cautiously added, to preserve adequate heat for finishing the journey.

It is hardly possible to convey in words alone a correct idea of the manipulations necessary to the formation of a wine bottle; but as the manufacturers make no mystery of this matter, any person may have an opportunity of inspecting the operation. Six people are employed at this task; one, called a gatherer, dips the end of an iron tube, about five feet long, previously made red-hot, into the pot of melted *metal*, turns the rod round so as to surround it with glass, lifts it out to cool a little, and then dips and turns it round again; and so in succession till a ball is formed on its end sufficient to make the required bottle. He then hands it to the blower, who rolls the plastic lump of glass on a smooth stone or cast-iron plate, till he brings it to the very end of the tube; he next introduces the pear-shaped ball into an open brass or cast-iron mould, shuts this together by pressing a pedal with his foot, and holding his tube vertically, blows through it, so as to expand the cooling glass into the form of the mould. Whenever he takes his foot from the pedal-lever, the mould spontaneously opens out into two halves, and falls asunder by its bottom hinge. He then lifts the bottle up at the end of the rod, and transfers it to the finisher, who, touching the glass tube at the end of the pipe with a cold iron, cracks off the bottle smoothly at its mouth-ring. The finished bottles are immediately piled up in the hot annealing arch, where they are afterwards allowed to cool slowly for 24 hours at least. See BOTTLE MOULD.

2. *Broad or spread window-glass.*—This kind of glass is called *inferior* window-glass, in this country, because coarse in texture, of a wavy wrinkled surface, and very cheap, but on the Continent *spread* window-glass, being made with more care, is much better than ours, though still far inferior in transparency and polish to crown glass, which has, therefore, nearly superseded its use among us. But Messrs. Chance and Hartley, of West Bromwich near Birmingham, have of late years mounted a spread-glass work, where they make *British sheet glass*, upon the best principles, and turn out an article quite equal, if not superior, to anything of the kind made either in France or Belgium. Their materials are those used in the crown-glass manufacture. The vitrifying mixture is fritted for 20 or 30 hours in a reverberatory arch, with considerable stirring and puddling with long-handled shovels and rakes; and the frit is then transferred by shovels, while red hot, to the melting pots to be founded. When the glass is rightly vitrified, settled, and brought to a working heat, it is lifted out by iron tubes, as will be described under the article CROWN GLASS, blown into pears, which being elongated into cylinders, are cracked up along one side, parallel to the axis, by touching them with a cold iron dipped in water, and are then opened out into sheets. Glass cylinders are spread in France, and at West Bromwich, on a bed of smooth stone Paris-plaster, or laid on the bottom of a reverberatory arch; the cylinder being placed on its side horizontally, with the cracked line uppermost, gradually opens out, and flattens on the hearth. At one time, thick plates were thus prepared for subsequent polishing into mirrors; but the glass was never of very good quality; and this mode of making mirror-plate has accordingly been generally abandoned.

The spreading furnace or oven is that in which cylinders are expanded into tables or plates. It ought to be maintained at a brisk red heat, to facilitate the softening of the glass. The oven is placed in immediate connexion with the annealing arch, so that the tables may be readily and safely transferred from the former to the latter. Sometimes the cylinders are spread in a large muffle furnace, in order to protect them from being tarnished by sulphureous and carbonaceous fumes.

Fig. 500 represents a ground plan of both the spreading and annealing furnace; *fig.* 501 is an oblong profile in the direction of the dotted line x x, *fig.* 500.

a is the fire-place; *b b* the canals or flues through which the flame rises into both furnaces; *c* the spreading furnace, upon whose sole is the spreading slab. *d* is the cooling and annealing oven; *e e* iron bars which extend obliquely across the annealing arch, and serve for resting the glass tables against, during the cooling. *f f* the channel along which the previously cracked cylinders are slid, so as to be gradually warmed;

the opening in the spreading furnace, for enabling the workmen to regulate the pro-

501
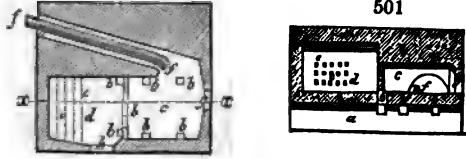
ss; *h* a door in the annealing arch, for introducing the tools requisite for raising up
d removing the tables.

In forming glass-plates by the extension of a cylinder into a plane, the workman first
ows the lump of glass into the shape of an oblong pear, the length of which must be
arly equal to the length of the intended plate, and its diameter such, that the circum-
rence, when developed, will be equal to the breadth of the plate. He now rests the
owing iron on a stool or iron bar, while an assistant, with a pointed iron, pierces a hole
to the extreme end of the pear, in the line of the blowing-pipe. This opening is then
larged, by introducing the blade of a pair of spring-tongs, while the glass is turned
and; and by skilful management, the end of the pear is eventually opened out into a
lindrical mouth. The workman next mounts upon a stool, and holds the blowing-iron
rpendicularly. The blown cylinder is now cracked off, a punto rod of iron having been
eviously stuck to its one end, to form a spindle for working the other by. This rod has
lat disc on its end, or three prongs, which being dipped in melted glass, are applied to
mouth of the cylinder. By this as a handle, the glass cone is carried to the fire, and
narrow end being heated, is next opened by spring tongs, and formed into a cylinder
the same size as the other end. The cylinder, thus equalized, is next cracked or slit
wn in its side with a pair of shears, laid on a smooth copper plate, detached from the
n rod, spread out by heat into a plane surface, and finally annealed. This series of
asformations is represented in *fig*. 502, at A, B, C, D, E, F, G, H.

Figs. 503 and 504 represent a Bohemian furnace in which excellent white window
ss is founded. *Fig.* 503 is a longitudinal section of the glass and annealing furnace.
g. 504 is the ground plan. *a* is the ash-pit vaulted under the sole of the furnace; the
-place itself is divided into three compartments; with a middle slab at *d*, which is hol-
ved in the centre, for collecting any split glass, and two hearth tiles or slabs *b b*. *c c*

A 502 D

503

504
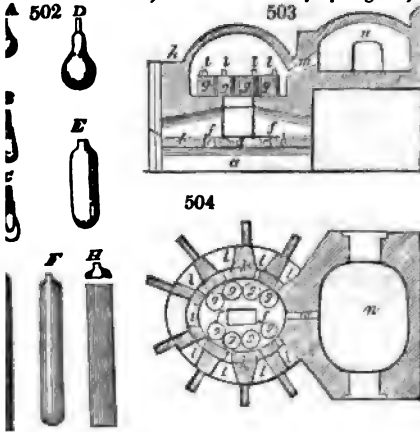
are the draught or air holes; *e e* are
arches upon which the bearing slabs
f f partly rest. In the middle be-
tween these arches, the flame strikes
upwards upon the pots *g g*, placed
as closely together as possible, for
economy of room. *h* is the breast
wall of the furnace; *i, fig.* 504, the
opening through which the pots are
introduced; it is bricked up as soon
as they are set. *k k*, is the base of
the cone or dome of the furnace;
l l l, the working orifices, which
are made larger or smaller accord-
ing to the size of the glass articles
to be made. *m* is the flue which
leads to the annealing stove *n*, with
an arched door. Exterior to this,
there is usually a drying kiln not
shown in the figure; and there are
adjoining stoves called *arches*, for

ing and annealing the new pots before they are set.

The cooling or annealing arch, or leer, is often built independent of the glass-house
nace, is then heated by a separate fire-place, and constructed like a very long rever-
atory furnace. See COPPER.

The leer pans or trays of sheet-iron, are laid upon its bottom in an oblong series, and
ked to each other.

l. *Crown-glass.*—The crown-glass house with its furnace is represented in *fig.* 505,
ere the *blowing* operation is shown on the one side of the figure, and the *flashing* on
other. The furnace is usually constructed to receive 4 or 6 pots, of such dimen-
ns as to make about a ton of glass each at a time. There are, however, several sub-

sidiary furnaces to a crown-house. 1. A reverberatory furnace or *calcar*, for calcining or
fritting the materials; 2. a blowing furnace, for blowing the pear-shaped balls, made at the pot-holes, into large globes; 3. a flashing furnace, and bottoming hole for communicating a soften-ing heat, in expanding the globe into a circular plate; 4. the annealing arch for the finished tables; 5. the reverberatory oven for annealing the pots prior to their being set upon the founding *siege*.
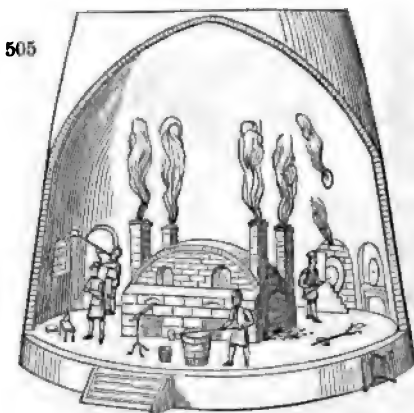
The materials of crown glass used to be, fine sand, by measure 5 parts, or by weight 10; ground kelp by measure 11 parts, or by weight $16\frac{1}{2}$; but instead of kelp, soda ash is now generally employed. From 6 to 8 c'wts. of sand, lime, and soda-ash, mixed together in wooden boxes with a shovel, are thrown on the sole of a large reverberatory, such as is represented in the article COPPER. Here the mixture is well worked together, with iron paddles, flat shovels, and rakes with long handles; the area of this furnace being about 6 feet square, and the height 2 feet. The heat soon brings the materials to a pasty con-sistence, when they must be diligently turned over, to favor the dissipation of the carbon, sulphur, and other volatile matters of the kelp or soda ash, and to incorporate the fixed ingredients uniformly with the sand. Towards the end of three hours, the fire is con-siderably raised, and when the fourth hour has expired, the fritting operation is finished. The mass is now shovelled or raked out into shallow cast-iron square cases, smoothed down, and divided, before it hardens by cooling, into square lumps, by cross sections with the spade. These frit-bricks are afterwards piled up in a large apartment for use; and have been supposed to improve with age, by the efflorescence of their saline constituents into carbonate of soda on their surface.

The founding-pots are filled up with these blocks of frit, and the furnace is powerfully urged by opening all the subterranean passages to its grate, and closing all the doors and windows of the glass-house itself. After 8 or 10 hours the vitrification has made such progress, and the blocks first introduced are so far melted down, that another charge of frit can be thrown in, and thus the pot is fed with frit till the proper quantity is used. In about 16 hours the vitrification of the frit has taken place, and a considerable quanti-ty, amounting often to the cwt. of liquid saline matter, floats over the glass. This salt is carefully skimmed off into iron pots with long ladles. It is called Sandiver or Glass-gall, and consists usually of muriate of soda, with a little sulphate. The pot is now ready for receiving the *topping of cullet*, which is broken pieces of window glass, to the amount of 3 or 4 cwts. This is shovelled in at short intervals; and as its pressure forces up the residuary saline matter, this is removed; for were it allowed to remain, the body of the glass would be materially deteriorated.

The heat is still continued for several hours till the glass is perfect, and the extrication of gas called the *boil*, which accompanies the fusion of crown glass, has nearly terminated, when the fire is abated, by shutting up the lower vault doors and every avenue to the grate, in order that the glass may settle fine. At the end of about 40 hours altogether, the fire being slightly raised by adding some coals, and opening the doors, the glass is carefully skimmed, and the working of the pots commences.

Before describing it, however, we may state that the marginal figure 506 shows the base of the crown-house cone, with the four open pots in two ranges on opposite sides of the furnace, sitting on their raised *sieges*, at each side of the grate. At one side of the base the door of the vault is shown, and its course is marked by the dotted lines.
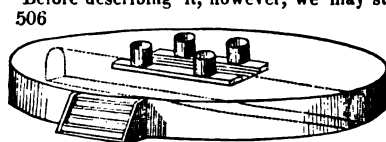
Detailed description of the crown-glass furnace, figs. 507, 508.—It is an oblong square, built in the centre of a brick cone, large enough to contain within it, two or three pots at each side of the grate room, which is either divided as shown in the plan, or runs the whole length of the furnace, as the manufacturer chooses. *Fig.* 507 is a ground plan, and *fig.* 508 a front elevation, of a six-pot furnace. 1, 2, 3, *fig.* 507, are the working holes

for the purposes of ventilation, of putting in the materials, and of taking out the metal to be wrought. 4, 5, 6, 7, are pipe holes for warming the pipes before beginning to work with them. 8, 9, 10, are foot holes for mending the pots and sieges. 11 is a bar of iron for binding the furnace, and keeping it from swelling.
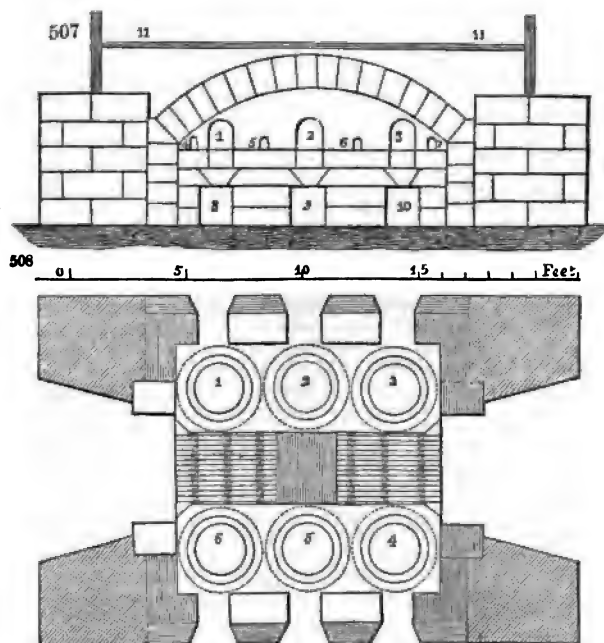
The arch is of an elliptic form; though a barrel arch, that is, an arch shaped like the half of a barrel cut longwise through the centre, is sometimes used. But this soon gives way when used in the manufacture of crown glass, although it does very well in the clay-furnace used for bottle houses.

The best stone for building furnaces is fire-stone, from Coxgreen in the neighborhood of Newcastle. Its quality is a close grit, and it contains a greater quantity of talc than the common fire-stone, which seems to be the chief reason of its resisting the fire better. The great danger in building furnaces is, lest the cement at the top should give way with the excessive heat, and by dropping into the pots, spoil the metal. The top should therefore be built with stones only, as loose as they can hold together after the centres are removed, and without any cement whatever. The stones expand and come quite close together when annealing; an operation which takes from eight to fourteen days at most. There is thus less risk of any thing dropping from the roof of the furnace.

The inside of the square of the furnace is built either of Stourbridge fire-clay annealed, or the Newcastle fire-stone, to the thickness of sixteen inches. The outside is built of common brick about nine inches in thickness.

The furnace is thrown over an ash-pit, or cave, as it is called, which admits the atmospheric air, and promotes the combustion of the furnace. This cave is built of stone until it comes beneath the grate room, when it is formed of fire-brick. The abutments are useful for binding and keeping the furnace together, and are built of masonry. The furnaces are stoutly clasped with iron all round, to keep them tight. In four-pot furnaces this is unnecessary, provided there be four good abutments.

Fig. 509 is an elevation of the flashing furnace. The outside is built of common brick, the inside of fire-brick, and the mouth or nose of Stourbridge fire-clay.

Fig. 510 is the annealing kiln. It is built of common brick, except round the grate room, where fire-brick is used.

Few tools are needed for blowing and flashing crown-glass. The requisite ball of plastic glass is gathered, in successive layers as for bottles, on the end of an iron tube, and rolled into a pear-shape, on a cast-iron plate; the workman taking care that the air blown into its cavity is surrounded with an equal body of glass, and if he perceives any side to be thicker than another, he corrects the inequality by rolling it on the sloping iron table called marver, (marbre). He now heats the bulb in the fire, and rolls it so as

to form the glass upon the end of the tube, and by a dexterous swing or two he lengthens it, as shown in I, *fig.* 511. To extend the neck of that pear, he next rolls it over a smooth iron rod, turned round in a horizontal direction, into the shape K, *fig.* 511. By further expansion at the blowing-furnace, he now brings it to the shape L, represented in *fig.* 511.

510

509

I K L 511
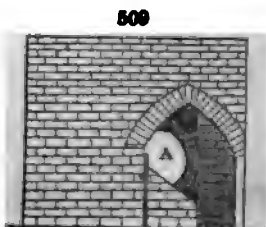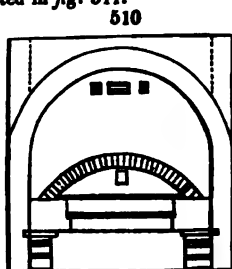
This spheroid having become cool and somewhat stiff, is next carried to the bottoming hole (like *fig.* 509), to be exposed to the action of flame. A slight wall erected before one half of this hole, screens the workman from the heat, but leaves room for the globe to pass between it and the posterior wall. The blowing-pipe is made to rest a little way from the neck of the globe, on a hook fixed in the front wall; and thus may be made easily to revolve on its axis, and by giving centrifugal force to the globe, while the bottom of it, or part opposite to the pipe, is softened by the heat, it soon assumes the form exhibited in M, *fig.* 511.

In this state the flattened globe is removed from the fire, and its rod being rested on the *casher box* covered with coal cinders, another workman now applies the end of a solid iron rod tipped with melted glass, called a *punto*, to the nipple or prominence in the middle; and thus attaches it to the centre of the globe, while the first workman cracks off the globe by touching its tubular neck with an iron chisel dipped in cold water. The workman having thereby taken possession of the globe by its bottom or knobbed pole attached to his punty rod, he now carries it to another circular opening, where he exposes it to the action of moderate flame with regular rotation, and thus slowly heats the thick projecting remains of the former neck, and opens it slightly out, as shown at N, in *fig.* 511. He next hands it to the *flasher*, who, resting the iron rod in a hook placed near the side of the orifice A, *fig.* 509, wheels it rapidly round opposite to a powerful flame, till it assumes first the figure o, and finally that of a flat circular table.

The flasher then walks off with the table, keeping up a slight rotation as he moves along, and when it is sufficiently cool, he turns down his rod into a vertical position, and lays the table flat on a dry block of fire-clay, or bed of sand, when an assistant nips it off from the *punto* with a pair of long iron shears, or cracks it off with a touch of cold iron. The loose table or plate is lastly lifted up horizontally on a double pronged iron fork, introduced into the annealing arch *fig.* 510 and raised on edge; an assistant with a long-kneed fork preventing it from falling too rapidly backwards. In this arch a great many tables of glass are piled up in iron frames, and slowly cooled from a heat of about 600° to 100° F., which takes about 24 hours; when they are removed. A circular plate or table of about 5 feet diameter weighs on an average 9 pounds.

4. *Flint glass.*—This kind of glass is so called because originally made with calcined flints, as the silicious ingredient. The materials at present employed in this country for the finest flint glass or crystal, are first, Lynn sand, calcined, sifted, and washed; second, an oxyde of lead, either red lead or litharge; and third, pearlash. The pearlash of commerce must however be purified by digesting it in a very little hot water, which dissolves the carbonate of potash, and leaves the foreign salts, chiefly sulphate of potash, muriate of potash, and muriate of soda. The solution of the carbonate being allowed to cool and become clear in lead pans, is then run off into a shallow iron boiler, and evaporated to dryness. Nitre is generally added as a fourth ingredient of the body of the glass; and it serves to correct any imperfections which might arise from accidental combustible particles, or from the lead being not duly oxydized. The above four substances constitute the main articles; to which we may add arsenic and manganese, introduced in very small quantities, to purify the color and clear up the transparency of the glass. The black oxyde of manganese, when used in such quantity only as to peroxydize the iron of the sand, simply removes the green tinge caused by the iron; but if more manganese be added than accomplishes that purpose, it will give a purple tinge to the glass; and in fact, most manufacturers prefer to have an excess rather than a defect of manganese, since cut glass has its brilliancy increased by a faint lilach hue. The arsenic is supposed to counteract the injury arising from excess of manganese, but is itself very apt on the other hand to communicate some degree of opalescence,

at least, to impair the lustre of the glass. When too much manganese has been ed, the purple tinge may indeed be removed by any carbonaceous matter, as by sting a wooden rod down into the liquid glass; but this cannot be done with good et in practice, since the final purple tinge is not decided till the glass is perfectly aed, and then the introduction of charcoal would destroy the uniformity of the whole teats of the pot.

he raw materials of flint glass are always mixed with about a third or a fourth of r weight of broken crystal of like quality; this mixture is thrown into the pot a shovel; and more is added whenever the preceding portions by melting subside; the et being to obtain a pot full of glass, to facilitate the skimming off the impurities and sandiver. The mouth of the pot is now shut, by applying clay-lute round the stopper, with the exception of a small orifice below, for the escape of the liquid saline matter. Flint glass requires about 48 hours for its complete vitrification, though the materials be more fusible than those of crown glass; in consequence of the contents of the pot being partially screened by its cover from the action of the fire, as also from the lower intensity of the heat.

Fig. 512 represents a flint glass house for 6 pots, with the arch or leer on one side for annealing the crystal ware. In *fig.* 513, the base of the cone is seen, and the glass pots *in situ* on their platform ranged round the central fire grate. The dotted line denotes the contour of the furnace, *fig.* 512.

Whenever the glass appears fine, and is freed from its air bubbles, which it usually is in about 36 hours, the heat is suffered to fall a little by closing the bottom valves, &c., that the pot may settle; but prior to working the metal the heat is *somewhat raised* again.

It would be useless to describe the manual operations of fashioning the ous articles of the flint-glass manufacture, because they are indefinitely varied to suit conveniences and caprices of human society.
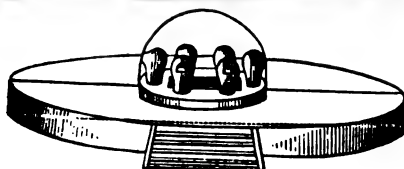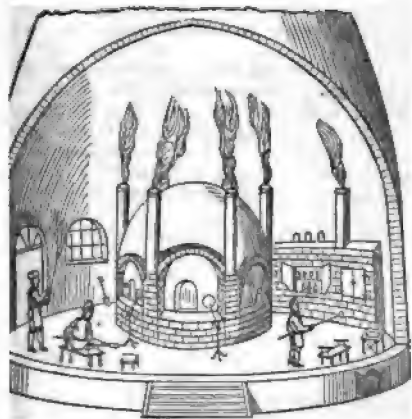
very different flint-house has a peculiar proportion of glass materials. The following been offered as good practical mixtures.

1. Fine white sand - - - - - - 300 parts.
   Red lead or litharge - - - - - 200
   Refined pearlashes - - - - - 80
   Nitre - - - - - - - 20
   Arsenic and manganese, a minute quantity.

my opinion, the proportion of lead is too great in the above recipe, which is given the authority of Mr. James Geddes, of Leith. The glass made with it would be ably yellowish and dull.

2. Fine sand - - - - - - - 50·5
   Litharge - - - - - - - - 27·2
   Refined pearlashes (carbonate of potash, with 5 per cent. of water) 17·5
   Nitre - - - - - - - - 4·8

                                                              100·0

o these quantities from 30 to 50 parts of broken glass or cullet are added; with about o-thousandth part of manganese, and a three-thousandth part of arsenic. But man-se varies so extremely in its purity, and contains often so much oxyde of iron, that ing can be predicated as to its quantity previously to trial.

Payen, an eminent manufacturing chemist in France, says that the composition of al does not deviate much from the following proportions:—

	Wood fire.	Coal fire.
Silicious sand - - - - -	3	3
Minium - - - - -	2	2¼
Carbonate of potash - - - -	1½	1¼

I conceive that this glass contains too much lead and potash. Such a mixture will produce a dull metal, very attractive of moisture; defects to which the French crown-glass also is subject.

The flint-glass *leer* for annealing glass, is an arched gallery or large flue, about 36 feet long, 3 feet high, 4 wide; having its floor raised above 2 feet above the ground of the glass-house. The hot air and smoke of a fire-place at one end pass along this gallery, and are discharged by a chimney 8 or 10 feet short of the other end. On the floor of the vault, large iron trays are laid and hooked to each other in a series, which are drawn from the fire end towards the other by a chain, wound about a cylinder by a winch-handle projecting through the side. The flint-glass articles are placed in their hot state into the tray next the fire, which is moved onwards to a cooler station whenever it is filled, and an empty tray is set in its place. Thus, in the course of about 20 hours, the glass advances to the cool end thoroughly annealed.

Besides colorless transparent glass, which forms the most important part of this manufacture, various colored glasses are made to suit the taste of the public. The taste at Paris was lately for opaline crystal; which may be prepared by adding to the above composition (No. 2) phosphate of lime, or well burnt bone ash in fine powder, washed and dried. The article must be as uniform in thickness as possible, and speedily worked into shape, with a moderate heat. Oxyde of tin, *putty*, was formerly used for making opalescent glass, but the lustre of the body was always impaired by its means.

Crystal vessels have been made recently of which the inner surface is colorless, and all the external facets colored. Such works are easily executed. The end of the blowing-rod must be dipped first in the pot containing colorless glass, to form a bulb of a certain size, which being cooled a little is then dipped for an instant into the pot of colored glass. The two layers are associated without intermixture; and when the article is finished in its form, it is white within and colored without. Fluted lines, somewhat deeply cut, pass through the colored coat, and enter the colorless one; so that when they cross, their ends alone are colored.

For some time past, likewise, various crystal articles have been exhibited in the market with colored enamel-figures on their surface, or with white incrustations of a silvery lustre in their interior. The former are prepared by placing the enamel object in the brass mould, at the place where it is sought to be attached. The bulb of glass being put into the mould, and blown while very hot, the small plate of enamel gets cemented to the surface. For making the white argentine incrustations, small figures are prepared with an impalpable-powder of dry porcelain paste, cemented into a solid by means of a little gypsum plaster. When these pieces are thoroughly dried, they are laid on the glass while it is red hot, and a large patch of very liquid glass is placed above it, so as to encase it and form one body with the whole. In this way the incrustation is completely enclosed; and the polished surface of the crystal, which scarcely touches it, gives a brilliant aspect, pleasing to the eye.

A uniform flint-glass, free from striæ, or *wreath*, is much in demand for the optician. It would appear that such an article was much more commonly made by the English manufacturers many years ago, than at present; and that in improving the brilliancy of crystal-glass they have injured its fitness for constructing optical lenses, which depends not so much on its whiteness and lustre as on the layers of different densities being parallel to each other. The oxyde of lead existing in certain parts of a potful of glass in greater proportion than in other parts, increases the density unequally in the same mass, so that the adjoining strata are often very different in this respect. Even a potful of pretty uniform glass, when it stands some time liquid, becomes eventually unequable by the subsidence of the denser portions; so that striæ and gelatinous appearances begin to manifest themselves, and the glass becomes of little value. Glass allowed to cool slowly in mass in the pot is particularly full of wreath; and if quickly refrigerated, that is, in two or three hours, it is apt to split into a multitude of minute splinters, of which no use can be made. For optical purposes, the glass must be taken out in its liquid state, being gathered on the end of the iron rod from the central portion of a recently skimmed pot, after the upper layers have been worked off in general articles.

M. Guinand, of Brennets near Geneva, appears to have hit upon processes that furnished almost certainly pieces of flint-glass capable of forming good lenses of remarkable dimensions, even of 11 inches diameter; of adequate density and transparency, and nearly free from *striæ*. M. Cauchoix, the eminent French optician, says, that out of ten object glasses, 4 inches in diameter, made with M. Guinand's flint glass, eight or nine turned out very good, while out of an equal number of object glasses made of the flint glass of the English and French manufactories, only one, or two at most, were found serviceable. The means by which M. Guinand arrived at these results have not been published. He has lately died, and it is not known whether his son be in possession of his secret.

atic object glass for telescopes and microscopes consists of at least two
ne made with glass of lead, or flint-glass, and the other with crown-glass;
ssessing a power of dispersing the colored rays relatively to its mean refrac-
uch greater than the latter; upon which principle the achromatism of the
uced, by reuniting the different colored rays into one focus. Flint-glass to
delicate purpose must be perfectly homogeneous, or of uniform density
substance, and free from wavy veins or wreaths; for every such inequal-
asion a corresponding inequality in the refraction and dispersion of the
iat is perceived in looking through a thick and thin solution of gum-arabic
ixed. Three plans have been prescribed for obtaining homogeneous pieces
ss: 1. to lift a mass of it in large ladles, and let it cool in them; 2. to
im the pots into moulds; 3. to allow it to cool in the pots, and afterwards
i horizontal strata. The last method, which is the most plausible, seldom
of uniform density, unless peculiar precautions have been adopted to settle
in uniform strata; because its materials are of such unequal density, the
having a specific gravity of 8, and silica of 2·7, that they are apt to stand
eights in the pots.
ause of these inequalities lies in the construction of the furnace, whereby
the pot is usually much less heated than the upper part. In a plate glass
emperature of the top of the pot has been found to be 130° Wedgew., while
iottom was only 110°, constituting a difference of no less than 2610° F.
y consequence is that the denser particles which subside to the bottom,
sion of the materials, and after the first extrication of the gases, must
, not being duly agitated by the expansive force of caloric, acting from
ls.
ation of the best optical glass is now made a great mystery by one or two
The following suggestions, deduced from a consideration of principles, may
to some improvements, if judiciously applied. The great object is to coun-
dency of the glass of lead to distribute itself into strata of different densi-
nay be effected either by mechanical agitation or by applying the greatest
ittom of the pot. But however homogeneous the glass may be thereby made,
: separation into strata of different densities must be prevented by rapid
ilidification. As the deeper the pots, the greater is the chance of unequal
ty in their contents, it would be advisable to make them wider and shal-
ose in use for making ordinary glass. The intermixture may be effected
ig the glass out of one pot into another in the furnace, and back again, with
or by stirring it up with a rouser, then allowing it to settle for a short
comes clear and free from air bubbles. The pot may now be removed from
n order to solidify its contents in their homogeneous state; after which the
broken in pieces, and be perfected by subjecting it to a second fusion; or,
and quicker, we may form suitable discs of glass without breaking down
lifting it out in flat copper ladles with iron shanks, and transferring the
little while into the annealing leer.
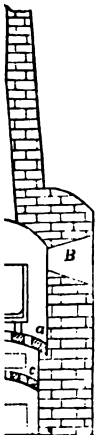
To render a potful of glass homogeneous by agitation, is a
more difficult task, as an iron rod would discolor it, and a
copper rod would be apt to melt. An iron rod sheathed in
laminated platinum would answer well, but for its expense.
A stone-ware tube supported within by a rod of iron, might
also be employed for the purpose in careful hands; the stir-
ring being repeated several times, till at last the glass is
suffered to stiffen a little by decrease of temperature. It
must then be allowed to settle and cool, after which the pot,
being of small dimensions, may be drawn out of the fire.

2. The second method of producing the desired uniformity
of mixture, consists in applying a greater heat to the bottom
than to the upper part of the melting pot. Fig. 514 repre-
sents in section a furnace contrived to effect this object. It
is cylindrical, and of a diameter no greater than to allow the
flames to play round the pot, containing from three to four
cwts. of vitreous materials. A is the pot, resting upon the
arched grid b a, built of fire-bricks, whose apertures are wide
enough to let the flames rise freely, and strike the bottom and
sides of the vessel. From 1½ to 2 feet under that arch, the
fuel grate c d is placed. B c are the two working openings
for introducing the materials, and inspecting the progress of
the fusion; they must be closed with fire-tiles and luted with
e beginning of the process. At the back of the furnace, opposite the mouth

of the fire-place there is a door-way, which is bricked up, except upon occasion of putting in and taking out the pot. The draught is regulated by means of a slide-plate upon the mouth of the ash-pit *f*. The pot being heated to the proper pitch, some purified pearlash, mixed with fully twice its weight of colorless quartz sand, is to be thrown into it, and after the complete fusion of this mixture, the remaining part of the sand along with the oxyde of lead (fine litharge) is to be strown upon the surface. These silicious particles in their descent serve to extricate the air from the mass. Whenever the whole is fused, the heat must be strongly urged, to ensure a complete uniformity of combination by the internal motions of the particles. As soon as the glass has been found, by making test vials, to be perfectly fine, the fire must be withdrawn, the two working holes must be opened, as well as the mouths of the fire-place and ash-pit, to admit free ingress to cooling currents of air, so as to congeal the liquid mass as quickly as possible; a condition essential to the uniformity of the glass. It may be worth while to stir it a little with the pottery rod at the commencement of the cooling process. The solidified glass may be afterwards detached by a hammer in conchoidal discs, which, after chipping off their edges, are to be placed in proper porcelain or stone-ware dishes, and exposed to a softening heat, in order to give them a lenticular shape. Great care must be taken that the heat thus applied by the muffle furnace be very equable, for otherwise wreaths might be very readily reproduced in the discs. A small oven, upon the plan of a baker's, is best fitted for this purpose, which being heated to dull redness, and then extinguished, is ready to soften and afterwards anneal the conchoidal pieces.

Guinand's dense optical flint glass, of specific gravity 3·616, consists, by analysis, of oxyde of lead, 43·05; silica, 44·3; and potash, 11·75; but requires for its formation the following ingredients: 100 pounds of ground quartz; 100 pounds of fine red lead; 35 pounds of purified potash; and from 2 to 4 pounds of saltpetre. As this species of glass is injured by an excess of potash, it should be compounded with rather a defect of it, and melted by a proportionably higher or longer heat. A good optical glass has been made in Germany with 7 parts of pure red lead, 3 parts of finely ground quartz, and 3 parts of calcined borax.

5. *Plate glass.*

This, like English crown-glass, has a soda flux; whereas flint-glass requires potash, and is never of good quality when made with soda. We shall distribute our account of this manufacture under two heads.

1. The different furnaces and principal machines, without whose knowledge it would be impossible to understand the several processes of a plate-glass factory.

2. The materials which enter into the composition of this kind of glass, and the series of operations which they undergo; devoting our chief attention to the changes and improvements which long experience, enlightened by modern chemistry, has introduced into the great manufactory of Saint-Gobin, in France, under the direction of M. Tassaert. It may however be remarked, that the English plate-glass manufacture derives peculiar advantages from the excellence of its grinding and polishing machinery.

The clay for making the bricks and pots should be free from lime and iron, and very refractory. It is mixed with the powder of old pots passed through a silk sieve. If the clay be very plastic it will bear its own weight of the powder, but if shorter in quality, it will take only three fifths. But before mingling it with the cement of old pots, it must be dried, bruised, then picked, ground, and finally elutriated by agitation with water, decantation through a hair sieve, and subsidence. The clay fluid after passing the sieve is called *slip* (coulis).

The furnace is built of dry bricks, cemented with slip, and has at each of its four angles a peculiar annealing arch, which communicates with the furnace interiorly, and thence derives sufficient heat to effect in part, if not wholly, the annealing of the pots, which are always deposited there a long time before they are used. Three of these arches, exclusively appropriated to this purpose, are called pot-arches. The fourth is called the *arch of the materials*, because it serves for drying them before they are founded. Each arch has, moreover, a principal opening called the throat, another called *bonnard*, by the French workmen, through which fire may be kindled in the arch itself, when it was thought to be necessary for the annealing of the pots; a practice now abandoned. The duration of a furnace is commonly a year, or at most 14 months; that of the arches is 30 years or upwards, as they are not exposed to so strong a heat.

In the manufacture of plate-glass two sorts of crucibles are employed, called the pots and the basins (*cuvettes*). The first serve for containing the materials to be founded, and for keeping them a long time in the melted state. The *cuvettes* receive the melted glass after it is refined, and decant it out on the table to be rolled into a plate. Three pots hold liquid glass for six small basins, or for three large ones, the latter being employed for making mirrors of great dimensions, that is, 100 inches long and up-

Furnaces have been lately constructed with 6 pots, and 12 cuvettes, 8 of which
l, and 4 large; and cuvettes of three sizes are made, called *small, middling,* and
The small are perfect cubes, the middling and the large ones are oblong parallel-
Towards the middle of their height, a notch or groove, two or three inches
id an inch deep, is left, called the girdle of the cuvette, by which part they are
with the tongs, or rather are clamped in the iron frame. This frame goes round
sides of the small cuvettes, and may be placed indifferently upon all their sides;
her cuvettes, the girdle extends only over the two large sides, because they can-
rued up. See *m* T, *fig.* 515, p. 596.
ot is an inverted truncated cone, like a crown glass pot. It is about 30 inches
l from 30 to 32 inches wide, including its thickness. There are only a few inches
ence between the diameter of the top and that of the bottom. The bottom is
thick, and the body turns gradually thinner till it is an inch at the mouth of the

rge building or factory, of which the melting furnace occupies the middle space,
the *halle* in French. At Ravenhead in Lancashire it is called the foundry, and
gnificent dimensions, being probably the largest apartment under one roof in
itain, since its length is 339 feet, and its breadth 155. The famous *halle* of St.
174 feet by 120. Along the two side walls of the *halle,* which are solidly con-
of hewn stone, there are openings like those of common ovens. These ovens,
for the annealing of the newly cast plates, bear the name of *carquaises.* Their
raised two feet and a half above the level of the ground, in order to bring them
ame horizontal plane with the casting tables. Their length, amounting some-
30 feet, and their breadth to 20, are required in order to accommodate 6, 8, or
plates of glass, alongside of each other. The front aperture is called the throat,
back door the little throat (*gueulette*). The carquaise is heated by means of a
of a square form called a *tisar,* which extends along its side.
unding or melting furnace is a square brick building laid on solid foundations,
m 8 to 10 feet in each of its fronts, and rising inside into a vault or crown about
igh. At each angle of this square, a small oven or arch is constructed, likewise
vithin, and communicating with the melting furnace by square flues, called *tu-*
rough which it receives a powerful heat, though much inferior to that round the
he arches are so distributed as that two of the exterior sides of the furnace stand
ee, while the two other sides, on which the arches encroach, offer a free space
hree feet. In this interjacent space, two principal openings of the furnace, of
e in each side, are left in the building. These are called tunnels. They are
for the introduction of the pots and the fuel.
king through the tunnels into the inside of the furnace, we perceive to the right
l the left, along the two *free* sides, two low platforms or *sieges,* at least 30 inches
and breadth. See *figs.* 506, 508.
sieges (seats) being intended to support the pots and the cuvettes filled with
aterials, are terminated by a slope, which ensures the solidity of the fire-clay
The slopes of the two sieges extend towards the middle of the furnace so near
ve a space of only from 6 to 10 inches between them for the hearth. . The end
s perforated with a hole sufficiently large to give passage to the liquid glass of a
ot, while the rest is preserved by lading it from the mouth into the adjoining

two large parallel sides of the furnace, other apertures are left much smaller
tunnels, which are called *ourreaux* (peep holes). The lower ones, or the *ouvreaux*
alled *cuvette* openings, because, being allotted to the admission of these vessels,
exactly on a level with the surface of the *sieges,* and with the floor of the *halle.*
: cast-iron form the thresholds of these openings, and facilitate the ingress and
' the cuvettes. The apertures are arched at top, with hewn stone like the tun-
l are 18 inches wide when the cuvettes are 16 inches broad.
pper and smaller apertures, or the higher *ouvreaux* called the *lading* holes, be-
ey serve for transvasing the liquid glass, are three in number, and are placed 31
hes above the surface of the *sieges.* As the pots are only 30 inches high, it
easy to work through these openings either in the pots or the *cuvettes.* The
d opposite to the two pillars which separate the openings, so that a space is left
them for one or more *cuvettes* according to the size of the latter. It is obvious
ae tunnels and *ouvreaux* were left open, the furnace would not draw or take the
founding heat. Hence the openings are shut by means of fire-tiles. These are
eir places, and removed by means of two holes left in them, in correspondence
two prongs of a large iron fork supported by an axle and two iron wheels, and
ed by two handles which the workmen lay hold of when they wish to move

losing of the tunnel is more complex. When it is shut or ready for the firing,

the aperture appears built up with bricks and mortar from the top of the arch to the middle of the tunnel. The remainder of the door-way is closed; 1. on the two sides down to the bottom, by a small upright wall, likewise of bricks, and 8 inches broad, called walls of the *glaye*; 2. by an assemblage of pieces called pieces of the *glaye*, because the whole of the closure of the tunnel bears the name of *glaye*. The upper hole, 4 inches square, is called the *tisar*, through which billets of wood are tossed into the fire. Fuel is also introduced into the posterior openings. The fire is always kept up on the hearth of the tunnel, which is, on this account, 4 inches higher than the furnace-hearth, in order that the glass which may accidentally fall down on it, and which does not flow off by the bottom hole, may not impede the combustion. Should a body of glass, however, at any time obstruct the grate, it must be removed with rakes, by opening the tunnel and dismounting the fire-tile stoppers of the *glaye*.

Formerly wood fuel alone was employed for heating the melting-furnaces of the mirror-plate manufactory of Saint Gobin; but within these few years, the Director of the works makes use with nearly equal advantage of pit-coal. In the same establishment, two melting furnaces may be seen, one of which is fixed with wood, and the other with coals, without any difference being perceptible in the quality of the glass furnished by either. It is not true, as has been stated, that the introduction of pit-coal has made it necessary to work with covered pots in order to avoid the discoloration of the material, or that more alkali was required to compensate for the diminished heat in the covered pots. They are not now covered when pit-coal is used, and the same success is obtained as heretofore by leaving the materials two or three hours longer in the pots and the cu-vettes. The construction of the furnaces in which coal is burned, is the same as that with wood, with slight modifications. Instead of the close bottomed hearth of the wood furnace, there is an iron grate in the coal-hearth through which the air enters, and the waste ashes descend.

When billets of wood were used as fuel, they were well dried beforehand, by being placed a few days on a frame-work of wood called the wheel, placed two feet above the furnace and its arches, and supported on four pillars at some distance from the angles of the building.

Composition of plate-glass.—This is not made now, as formerly, by random trials. The progress of chemistry, the discovery of a good process for the manufacture of soda from sea salt, which furnishes a pure alkali of uniform power, and the certain methods of ascertaining its purity, have rendered this department of glass-making almost entirely new, in France. At Saint Gobin no alkali is employed at present except artificial crystals of soda, prepared at the manufactory of Chauny, subsidiary to that establish-ment. Leaden chambers are also erected there for the production of sulphuric acid from sulphur. The first crop of soda crystals is reserved for the plate-glass manufac-ture, the other crystals and the mother-water salts are sold to the makers of inferior glass.

At the mirror-plate works of Ravenhead, near St. Helen's in Lancashire, soda crys-tals, from the decomposition of the sulphate of soda by chalk and coal, have been also tried, but without equal success as at Saint Gobin; the failure being unquestionably due to the impurity of the alkali. Hence, in the English establishment the soda is obtained by treating sea-salt with pearl-ash, whence carbonate of soda and muriate of potash re-sult. The latter salt is crystallized out of the mingled solution, by evaporation at a mod-erate heat, for the carbonate of soda does not readily crystallize till the temperature of the solution falls below 60° Fahr. When the muriate of potash is thus removed, the alkaline carbonate is evaporated to dryness.

Long experience at Saint Gobin has proved that one part of dry carbonate of soda is adequate to vitrify perfectly three parts of fine silicious sand, as that of the mound of Aumont near Senlis, of Alum Bay in the Isle of Wight, or of Lynn in Norfolk. It is also known that the degree of heat has a great influence upon the vitrification, and that increase of temperature will compensate for a certain deficiency of alkali; for it is certain that a very strong fire always dissipates a good deal of the soda, and yet the glass is not less beautiful. The most perfect mirror-plate has constantly afforded to M. Vau-quelin in analysis, a portion of soda inferior to what had been employed in its formation. Hence, it has become the practice to add for every 100 parts of cullet or broken plate that is mixed with the glass composition, one part of alkali, to make up for the loss that the old glass must have experienced.

To the above mentioned proportions of sand and alkali independently of the cullet which may be used, dry slaked lime carefully sifted is to be added to the amount of one seventh of the sand; or the proportion will be, sand 7 cwts.; quicklime 1 cwt.; dry carbonate of soda 2 cwts. and 37 lbs.; besides cullet. The lime improves the quality of the glass; rendering it less brittle and less liable to change. The preceding quantities of materials, suitably blended, have been uniformly found to afford most advantageous results. The practice formerly was to dry that mixture as soon as it was made, in the

arch for the materials, but it has been ascertained that this step may be dispensed with, and the small portion of humidity present is dissipated almost instantly after they are thrown into the furnace. The coat of glaze previously applied to the inside of the pot, prevents the moisture from doing them any harm. For this reason, when the demand for glass at Saint-Gobin is very great, the materials are neither fritted nor even dried, but shovelled directly into the pot; this is called founding *raw.* Six workmen are employed in shovelling-in the materials either fritted or otherwise, for the sake of expedition, and to prevent the furnace getting cooled. One third of the mixture is introduced at first; whenever this is melted, the second third is thrown in, and then the last. These three stages are called the first, second, and third fusion or founding.

According to the ancient practice, the founding and refining were both executed in the pots, and it was not till the glass was refined, that it was laded into the cuvettes, where it remained only 3 hours, the time necessary for the disengagement of the air bubbles introduced by the transvasion, and for giving the *metal* the proper consistence for casting. At present, the period requisite for founding and refining, is equally divided between the pots and the *cuvettes.* The materials are left 16 hours in the pots, and as many in the *cuvettes;* so that in 32 hours the glass is ready to be cast. During the last two or three hours, the fireman or *tiseur* ceases to add fuel; all the openings are shut, and the glass is allowed to assume the requisite fluidity; an operation called *stopping* the glass, or *performing the ceremony.*

The transfer of the glass into the *cuvettes,* is called *lading,* (*tréjetage*). Before this is done, the cuvettes are cleared out, that is, the glass remaining on their bottom is removed, and the ashes of the firing. They are lifted red hot out of the furnace by the method presently to be described, and placed on an iron plate, near a tub filled with water. The workmen, by means of iron paddles 6 feet long, flattened at one end and hammered to an edge, scoop out the fluid glass expeditiously, and throw it into water; the *cuvettes* are now returned to the furnace, and a few minutes afterwards the lading begins.

In this operation, ladles of wrought iron are employed, furnished with long handles, which are plunged into the pots through the upper openings or lading holes, and immediately transfer their charge of glass into the buckets. Each workman dips his ladle only three times, and empties its contents into the cuvette. By these three immersions (whence the term *tréje'er* is derived), the large iron spoon is heated so much that when plunged into a tub full of water, it makes a noise like the roaring of a lion, which may be heard to a very great distance.

The founding, refining, and *ceremony,* being finished, they next try whether the glass be ready for casting. With this view, the end of a rod is dipped into the bucket, which is called *drawing the glass;* the portion taken up being allowed to run off, naturally assumes a pear-shape, from the appearance of which, they can judge if the consistence be proper, and if any air bubbles remain. If all be right, the *cuvettes* are taken out of the furnace, and conveyed to the part of the *halle* where their contents are to be poured out. This process requires peculiar instruments and manipulations.

Casting.—While the glass is refining, that is, coming to its highest point of perfection, preparation is made for the most important process, the casting of the plate, whose success crowns all the preliminary labors and cares. The oven or *carquaise* destined to receive and anneal the plate is now heated by its small fire or *tisar,* to such a pitch that its sole may have the same temperature as that of the plates, being nearly red-hot at the moment of their being introduced. An unequal degree of heat in the *carquaise* would cause breakage of the glass. The casting table is then rolled towards the front door or throat, by means of levers, and its surface is brought exactly to the level of the sole of the oven.

The table **T**, *fig.* 515, is a mass of bronze, or now preferably cast iron, about 10 feet long, 5 feet broad, and from 6 to 7 inches thick, supported by a frame of carpentry, which rests on three cast iron wheels. At the end of the table opposite to that next to the front of the oven, is a very strong frame of timber-work, called the puppet or standard, upon which the bronze roller which spreads the glass is laid, before and after the casting. This is 5 feet long by 1 foot in diameter; it is thick in the metal but hollow in the axis. The same roller can serve only for two plates at one casting, when another is put in its place, and the first is laid aside to cool; for otherwise the hot roller would at a third casting make the plate expand unequally, and cause it to crack. When the rollers are not in action, they are laid aside in strong wooden trestles, like those employed by sawyers. On the two sides of the table in the line of its length, are two parallel bars of bronze, *t, t,* destined to support the roller during its passage from end to end; the thickness of these bars determines that of the plate. The table being thus arranged, a crane is had recourse to for lifting the cuvette, and keeping it suspended, till it be emptied upon the table. This raising and suspension are effected by means of an iron gib, furnished with pulleys, held horizontally, and which turns with them.

The tongs T, *fig.* 515, are made of four iron bars, bent into a square frame in their middle, for embracing the bucket. Four chains proceeding from the corners of the frame v, are united at their other ends into a ring which fits into the hook of the crane.

515
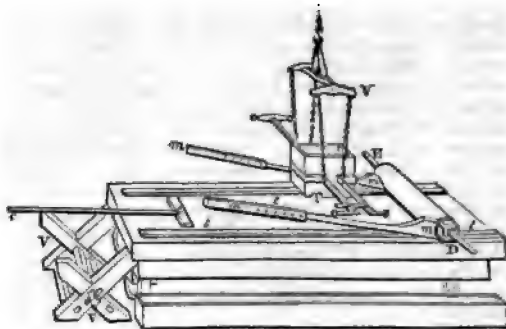
Things being thus arranged, all the workmen of the foundry co-operate in the manipulations of the casting. Two of them fetch, and place quickly in front of one of the lower openings, the small cuvette-carriage, which bears a forked bar of iron, having two prongs corresponding to the two holes left in the fire-tile door. This fork, mounted on the axle of two cast-iron wheels, extends at its other end into two branches terminated by handles, by which the workmen move the fork, lift out the tile stopper, and set it down against the outer wall of the furnace.

The instant these men retire, two others push forward into the opening the extremity of the tongs-carriage, so as to seize the bucket by the girdle, or rather to clamp it. At the same time, a third workman is busy with an iron pinch or long chisel, detaching the bucket from its seat, to which it often adheres by some spilt glass; whenever it is free, he withdraws it from the furnace. Two powerful branches of iron united by a bolt, like two scissor blades, which open, come together, and join by a quadrant near the other end, form the tongs-carriage, which is mounted upon two wheels like a truck.

The same description will apply almost wholly to the iron-plate carriage, on which the bucket is laid the moment it is taken out of the furnace; the only difference in its construction is, that on the bent iron bars which form the tail or lower steps of this carriage (in place of the tongs) is permanently fastened an iron plate, on which the bucket is placed and carried for the casting.

Whenever the *cuvette* is set upon its carriage, it must be rapidly wheeled to its station near the crane. The tongs T above described are now applied to the girdle, and are then hooked upon the crane by the suspension chains. In this position the bucket is skimmed by means of a copper tool called a sabre, because it has nearly the shape of that weapon. Every portion of the matter removed by the sabre is thrown into a copper ladle (*poche de gamin*), which is emptied from time to time into a cistern of water. After being skimmed, the bucket is lifted up, and brushed very clean on its sides and bottom; then by the double handles of the suspension-tongs it is swung round to the table, where it is seized by the workmen appointed to turn it over; the roller having been previously laid on its ruler-bars, near the end of the table which is in contact with the annealing oven. The *cuvette*-men begin to pour out towards the right extremity E of the roller, and terminate when it has arrived at the left extremity D. While preparing to do so, and at the instant of casting, two men place within the ruler-bar on each side, that is, between the bar and the liquid glass, two iron instruments called *hands*, m, m, m, m, which prevent the glass from spreading beyond the rulers, while another draws along the table the wiping bar c, c, wrapped in linen, to remove dust, or any small objects which may interpose between the table and the liquid glass.

Whenever the melted glass is poured out, two men spread it over the table, guiding the roller slowly and steadily along, beyond the limits of the glass, and then run it smartly into the wooden standard prepared for its reception, in place of the trestles v, v.

The empty bucket, while still red-hot, is hung again upon the crane, set on its plate-iron carriage, freed from its tongs, and replaced in the furnace, to be speedily cleared out anew, and charged with fresh fluid from the pots. If while the roller glides along, the two workmen who stand by with picking tools, perceive *tears* in the matter in advance of the roller, and can dexterously snatch them out, they are suitably rewarded, according to the spot where the blemish lay, whether in the centre, where it would have proved most detrimental, or near the edge. These tears proceed usually from

1 portions of semi-vitrified matter which fall from the vault of the furnace, and from
· density occupy the bottom of the *cuvettes.*

'hile the plate is still red-hot and ductile, about 2 inches of its end opposite to the
waise door is turned up with a tool; this portion is called the *head of the mirror ;*
nst the outside of this head, the shovel, in the shape of a rake without teeth, is ap-
l, with which the plate is eventually pushed into the oven, while two other workmen
s upon the upper part of the head with a wooden pole, eight feet long, to preserve
plate in its horizontal position, and prevent its being warped. The plate is now left
l few moments near the throat of the *carquaise,* to give it solidity; after which it is
led farther in by means of a very long iron tool, whose extremity is forked like the
r y, and hence bears that name; and is thereby arranged in the most suitable spot for
ving other plates to be introduced.

owever numerous the manipulations executed from the moment of withdrawing the
tte from the furnace, till the cast-plate is pushed into the annealing oven, I have seen
a all performed in less than five minutes; such silence, order, regularity, and despatch
·ail in the establishment of Saint-Gobin.

'hen all the plates of the same casting have been placed in the *carquaise,* it is sealed
that is to say, all its orifices are closed with sheets of iron, surrounded and made tight
l plastic loam. With this precaution, the cooling goes on slowly and equably in every
, for no cooling current can have access to the interior of the oven.

fter they are perfectly cooled, the plates are carefully withdrawn one after another,
ring them all the while in a horizontal position, till they are entirely out of the *car-*
ise. As soon as each plate is taken out, one set of workmen lower quickly and
dily the edge which they hold, while another set raise the opposite edge, till the glass
placed upright on two cushions stuffed with straw, and covered with canvass. In
vertical position they pass through, beneath the lower edge of the plate, three girths
traps each four feet long, thickened with leather in their middle, and ending in
den handles; so that one embraces the middle of the plate, and the other two, the
l. The workmen, six in number, now seize the handles of the straps, lift up the
s closely to their bodies, and convey it with a regular step to the warehouse. Here
head of the plate is first cut off with a diamond square, and then the whole is atten-
ly examined, in reference to its defects and imperfections, to determine the sections
sh must be made of it, and the eventual size of the pieces. The pairings and small
ings detached are set aside, in order to be ground and mixed with the raw materials
mother glass-pot.

he apartment in which the roughing-down and smoothing of the plates is performed,
irnished with a considerable number of stone tables truly hewn and placed apart like
ard tables, in a horizontal position, about 2 feet above the ground. They are rec-
rular, and of different sizes proportional to the dimensions of the plates, which they
ht always to exceed a little. These tables are supported either on stone pillars or
den frames, and are surrounded with a wooden board whose upper edge stands some-
t below their level, and leaves in the space between it and the stone all round an in-
al of 3 or 4 inches, of which we shall presently see the use.

. cast plate, unless formed on a table quite new, has always one of its faces, the one
t the table, rougher than the other; and with this face the roughing-down begins.
h this view, the smoother face is cemented on the stone table with Paris-plaster. But
n, instead of one plate, several are cemented alongside of each other, those of the same
kness being carefully selected. They then take one or more crude plates of about one
d or one fourth the surface of the plate fixed to the table, and fix it on them with
id gypsum to the large base of a quadrangular truncated pyramid of stone, of a weight
ortioned to its extent, or about a pound to the square inch. This pyramidal muller,
nall sized, bears at each of its angles of the upper face a peg or ball, which the
ders lay hold of in working it; but when of greater dimension, there is adapted to it
zontally a wheel of slight construction, 8 or 10 feet in diameter, whose circumference
ade of wood rounded so as to be seized with the hand. The upper plate is now
ved over the lower ones, with moistened sand applied between.

'his operation is however performed by machinery. The under plate being fixed or
edded in stucco, on a solid table, the upper one likewise imbedded by the same
ent in a cast iron frame, has a motion of circumrotation given to it closely resem-
g that communicated by the human hand and arm, moist sand being supplied
veen them. While an eccentric mechanism imparts this double rotatory movement
he upper plate round its own centre, and of that centre round a point in the lower
e, this plate, placed on a moveable platform, changes its position by a slow horizontal
ion, both in the direction of its length and its breadth. By this ingenious con-
ince, which pervades the whole of the grinding and polishing machinery, a remark-
regularity of friction and truth of surface is produced. When the plates are suffi-
tly worked on one face, they are reversed in the frames, and worked together on

the other. The Paris plaster is usually colored red, in order to show any defects in the glass.

The smoothing of the plates is effected on the same principles by the use of moist emery washed to successive degrees of fineness, for the successive stages of the operation; and the polishing process is performed by rubbers of hat-felt and a thin paste of colcothar and water. The colcothar, called also crocus, is red oxyde of iron prepared by the ignition of copperas, with grinding and elutriation of the residuum.

The last part or the polishing process is performed by hand. This is managed by females, who slide one plate over another, while a little moistened putty of tin finely levigated is thrown between.

Large mirror-plates are now the indispensable ornaments of every large and sumptuous apartment; they diffuse lustre and gayety round them, by reflecting the rays of light in a thousand lines, and by multiplying indefinitely the images of objects placed between opposite parallel planes.

The *silvering* of *plane* mirrors consists in applying a layer of tin-foil alloyed with mercury to their posterior surface. The workshop for executing this operation is provided with a great many smooth tables of fine freestone or marble, truly levelled, having round their contour a rising ledge, within which there is a gutter or groove which terminates by a slight slope in a spout at one of the corners. These tables rest upon an axis of wood or iron which runs along the middle of their length; so that they may be inclined easily into an angle with the horizon of 12 or 13 degrees, by means of a hand-screw fixed below. They are also furnished with brushes, with glass rules, with rolls of woollen stuff, several pieces of flannel, and a great many weights of stone or cast-iron.

The glass-tinner, standing towards one angle of his table, sweeps and wipes its surface with the greatest care, along the whole surface to be occupied by the mirror-plate; then taking a sheet of tin-foil adapted to his purpose, he spreads it on the table, and applies it closely with a brush, which removes any folds or wrinkles. The table being horizontal, he pours over the tin a small quantity of quicksilver, and spreads it with a roll of woollen stuff; so that the tin-foil is penetrated and apparently dissolved by the mercury. Placing now two rules, to the right and to the left, on the borders of the sheet, he pours on the middle a quantity of mercury sufficient to form everywhere a layer about the thickness of a crown piece; then removing with a linen rag the oxyde or other impurities, he applies to it the edge of a sheet of paper, and advances it about half an inch. Meanwhile another workman is occupied in drying very nicely the surface of the glass that is to be silvered, and then hands it to the master workman, who, laying it flat, places its anterior edge first on the table, and then on the slip of paper; now pushing the glass forwards, he takes care to slide it along so that neither air nor any coat of oxyde on the mercury can remain beneath the plate. When this has reached its position, he fixes it there by a weight applied on its side, and gives the table a gentle slope, to run off all the loose quicksilver by the gutter and spout. At the end of five minutes he covers the mirror with a piece of flannel, and loads it with a great many weights which are left upon it for twenty-four hours, under a gradually increased inclination of the table. By this time the plate is ready to be taken off the marble table, and laid on a wooden one sloped like a reading desk, with its under edge resting on the ground, while the upper is raised successively to different elevations by means of a cord passing over a pulley in the ceiling of the room. Thus the mirror has its slope graduated from day to day, till it finally arrives at a vertical position. About a month is required for draining out the superfluous mercury from large mirrors; and from 18 to 20 days from those of moderate size. The sheets of tin-foil being always somewhat larger than the glass-plate, their edges must be paired smooth off, before the plate is lifted off the marble table.

Process for silvering concave mirrors.—Having prepared some very fine Paris plaster by passing it through a silk sieve, and some a little coarser passed through hair-cloth, the first is to be made into a creamy liquor with water, and after smearing the concave surface of the glass with a film of olive oil, the fine plaster is to be poured into it, and spread by turning about, till a layer of plaster be formed about a tenth of an inch thick. The second or coarse plaster, being now made into a thin paste, poured over the first, and moved about, readily incorporates with it, in its imperfectly hardened state. Thus an exact mould is obtained of the concave surface of the glass, which lies about three quarters of an inch thick upon it, but is not allowed to rise above its outer edge.

The mould, being perfectly dried, must be marked with a point of coincidence on the glass, in order to permit of its being exactly replaced in the same position, after it has been lifted out. The mould is now removed, and a round sheet of tin-foil is applied to it, so large that an inch of its edge may project beyond the plaster all round; this border being necessary for fixing the tin to the contour of the mould by pellets of white wax softened a little with some Venice turpentine. Before fixing the tin-foil, however, it must be properly spread over the mould, so as to remove every wrinkle; which the

pliancy of the foil easily admits of, by uniform and well-directed pressure with the fingers.

The glass being placed in the hollow bed of a tight sack filled with fine sand, set in a well-jointed box, capable of retaining quicksilver, its concave surface must be dusted with sifted wood-ashes, or Spanish white contained in a small cotton bag, and then well wiped with clean linen rags, to free it from all adhering impurity, and particularly the moisture of the breath. The concavity must be now filled with quicksilver to the very lip, and the mould, being dipped a little way into it, is withdrawn, and the adhering mercury is spread over the tin with a soft flannel roll, so as to amalgamate and brighten its whole surface, taking every precaution against breathing on it. Whenever this brightening seems complete, the mould is to be immersed, not vertically, but one edge at first, and thus obliquely downwards till the centres coincide; the mercury meanwhile being slowly displaced, and the mark on the mould being brought finally into coincidence with the mark on the glass. The mould is now left to operate by its own weight, in expelling the superfluous mercury, which runs out upon the sand-bag and thence into a groove in the bottom of the box, whence it overflows by a spout into a leather bag of reception. After half an hour's repose, the whole is cautiously inverted, to drain off the quicksilver more completely. For this purpose, a box like the first is provided with a central support rising an inch above its edges; the upper surface of the support being nearly equal in diameter to that of the mould. Two workmen are required to execute the following operation. Each steadies the mould with the one hand, and raises the box with the other, taking care not to let the mould be deranged, which they rest on the (convex) support of the second box. Before inverting the first apparatus, however, the reception bag must be removed, for fear of spilling its mercury. The redundant quicksilver now drains off; and if the weight of the sandbag is not thought sufficient, supplementary weights are added at pleasure. The whole is left in this position for two or three days. Before separating the mirror from its mould, the border of tin-foil, fixed to it with wax, must be pared off with a knife. Then the weight and sandbag being removed, the glass is lifted up with its interior coating of tin-amalgam.

For silvering a convex surface.—A concave plaster mould is made on the convex glass, and their points of coincidence are defined by marks. This mould is to be lined with tinfoil, with the precautions above described; and the tin surface being first brightened with a little mercury, the mould is then filled with the liquid metal. The glass is to be well cleaned, and immersed in the quicksilver bath, which will expel the greater part of the metal. A sandbag is now to be laid on the glass, and the whole is to be inverted as in the former case on a support; when weights are to be applied to the mould, and the mercury is left to drain off for several days.

If the glass be of large dimensions, 30 or 40 inches, for example, another method is adopted. A circular frame or hollow ring of wood or iron is prepared, of twice the diameter of the mirror, supported on three feet. A circular piece of new linen cloth of close texture is cut out, of equal diameter to the ring, which is hemmed stoutly at the border, and furnished round the edge with a row of small holes, for lacing the cloth to the ring, so as to leave no folds in it, but without bracing it so tightly as to deprive it of the elasticity necessary for making it into a mould. This apparatus being set horizontally, a leaf of tinfoil is spread over it, of sufficient size to cover the surface of the glass; the tin is first brightened with mercury, and then as much of the liquid metal is poured on as a plane mirror requires. The convex glass, well cleaned, is now set down on the cloth, and its own weight, joined to some additional weights, gradually presses down the cloth, and causes it to assume the form of the glass which thus comes into close contact with the tin submersed under the quicksilver. The redundant quicksilver is afterwards drained off by inversion, as in common cases.

The following recipe has been given for silvering the inside of glass globes. Melt in an iron ladle or a crucible, equal parts of tin and lead, adding to the fused alloy one part of bruised bismuth. Stir the mixture well, and pour into it as it cools, two parts of dry mercury; agitating anew and skimming off the drossy film from the surface of the amalgam. The inside of the glass globe, being freed from all adhering dust and humidity, is to be gently heated, while a little of the semi-fluid amalgam is introduced. The liquidity being increased by the slight degree of heat, the metallic coating is applied to all the points of the glass, by turning round the globe in every direction, but so slowly as to favor the adhesion of the alloy. This silvering is not so substantial as that of plane mirrors: but the form of the vessel, whether a globe, an ovoid, or a cylinder, conceals or palliates the defects by counter reflection from the opposite surfaces.

Colored Glasses and Artificial Gems.—The general vitreous body preferred by Fontanieu in his treatise on this subject, which he calls the Mayence base, is prepared in the following manner. Eight ounces of pure rock-crystal or flint in powder, mixed with 24 ounces of salt of tartar, are baked and left to cool. This is afterwards poured

into a basin of hot water, and treated with dilute nitric acid till it ceases to effervesce; when the frit is to be washed till the water comes off tasteless. The frit is now dried and mixed with 12 ounces of fine white lead, and the mixture is to be levigated and elutriated with a little distilled water. An ounce of calcined borax is to be added to about 12 ounces of the preceding mixture in a dry state, the whole rubbed together in a porcelain mortar, then melted in a clean crucible, and poured out into cold water. This vitreous matter must be dried, and melted a second and a third time, always in a new crucible, and after each melting poured into cold water as at first, taking care to separate the lead that may be revived. To the last glass ground to powder, five drachms of nitre are to be added, and the mixture being melted for the last time, a mass of crystal will be found in the crucible with a beautiful lustre. The diamond is well imitated by this Mayence base. Another very fine white crystal may be obtained, according to M. Fontanieu, from eight ounces of white lead, two ounces of powdered borax, half a grain of manganese, and three ounces of rock-crystal, treated as above.

The colors of artificial gems are obtained from metallic oxydes. The *oriental topaz* is prepared by adding oxyde of antimony to the base; the amethyst from manganese, with a little purple precipitate of Cassius; the beryl from antimony and a very little cobalt; yellow artificial diamond and opal from horn-silver (chloride of silver); blue stone from cobalt. See PASTES and PIGMENTS VITRIFIABLE.

The following are recipes for making the different kinds of glass.

1. *Bottle glass.*—11 pounds of dry glauber salts; 12 pounds of soaper salts; a half bushel of waste soap ashes; 56 pounds of sand; 22 pounds of glass skimmings; 1 cwt. of green broken glass; 25 pounds of basalt. This mixture affords a dark green glass.

2. Yellow or white sand, 100 parts; kelp, 30 to 40; lixiviated wood ashes, from 160 to 170 parts; fresh wood ashes, 30 to 40 parts; potter's clay, 80 to 100 parts; cullet or broken glass, 100. If basalt be used, the proportion of kelp may be diminished.

In two bottle-glass houses in the neighborhood of Valenciennes, an unknown ingredient, sold by a Belgian, was employed, which he called *spar*. This was discovered by chemical analysis to be sulphate of baryta. The glass-makers observed that the bottles which contained some of this substance were denser, more homogeneous, more fusible, and worked more kindly, than those formed of the common materials. When one prime equivalent of the silicate of baryta = 123, is mixed with three primes of the silicate of soda = (3 × 77·6) 232·8, and exposed in a proper furnace, vitrification readily ensues, and the glass may be worked a little under a cherry red heat, with as much ease as a glass of lead, and has nearly the same lustre. Since the ordinary run of glass-makers are not familiar with atomic proportions, they should have recourse to a scientific chemist, to guide them in using such a proportion of sulphate of baryta as may suit their other vitreous ingredients; for an excess or defect of any of them will injure the quality of the glass.

3. *Green window glass, or broad glass.*—11 pounds of dry glauber salts; 10 pounds of soaper salts; half a bushel of lixiviated soap waste; 50 pounds of sand; 22 pounds of glass pot skimmings; 1 cwt. of broken green glass.

4. *Crown glass.*—300 parts of fine sand; 200 of good soda ash; 33 of lime; from 250 to 300 of broken glass; 60 of white sand; 30 of purified potash; 15 of saltpetre (1 of borax); ½ of arsenious acid.

5. *Nearly white table glass.*—20 pounds of potashes; 11 pounds of dry glauber salts; 16 of soaper salt; 55 of sand; 140 of cullet of the same kind. Another.—100 of sand; 235 of kelp; 60 of wood ashes; 1½ of manganese; 100 of broken glass.

6. *White table glass.*—40 pounds of potashes; 11 of chalk; 76 of sand; ¼ of manganese; 95 of white cullet.

Another.—50 of purified potashes; 100 of sand; 20 of chalk; and 2 of saltpetre.

Bohemian table or plate glass is made with 63 parts of quartz; 26 of purified potashes; 11 of sifted slaked lime, and some cullet.

7. *Crystal glass.*—60 parts of purified potashes; 120 of sand; 24 of chalk; 2 of saltpetre; 2 of arsenious acid; $\frac{1}{16}$ of manganese.

Another.—70 of purified pearlashes; 120 of white sand; 10 of saltpetre; ½ of arsenious acid; ¼ of manganese.

A third.—67 of sand; 23 of purified pearlashes; 10 of sifted slaked lime; ¼ of manganese; (5 to 8 of red lead).

A fourth.—120 of white sand; 50 of red lead; 40 of purified pearlash; 20 of saltpetre; ⅛ of manganese.

A fifth.—120 of white sand; 40 of pearlash purified; 35 of red lead; 13 of saltpetre; 1½ of manganese.

A sixth.—30 of the finest sand; 20 of red lead; 8 of pearlash purified; 2 of saltpetre; a little arsenious acid and manganese.

enth.—100 of sand; 45 of red lead; 35 of purified pearlashes; $\frac{1}{7}$ of manganese; enious acid.

ate glass.—Very white sand 300 parts; dry purified soda 100 parts; carbonate 43 parts; manganese 1; cullet 300.

er.—Finest sand 720; purified soda 450; quicklime 80 parts; saltpetrre 25 ullet 425.

e borax has also been prescribed; much of it communicates an exfoliating pro-glass.

Tabular view of the composition of several kinds of Glass.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.
- -	71·7	69·2	62·8	69·2	60·4	53·55	59·2	51·93	42·5
-	12·7	15·8	22·1	8·0	3·2	5·48	9·0	13·77	11·7
- -	2·5	3·0		3·0	S. pot.				
- -	10·3	7·6	12·5	13·0	20·7	29·22			0·5
ia -	0·4	1·2		3·6	10·4	6·01			1·8
sia -		2·0	} 2·6	0·6	0·6				
of iron	0·3	0·5		1·6	3·8	5·74	0·4		
nanganese	0·2						1·0		
ead -							28·2	33·28	43·5
-					0·9				

is a very beautiful white wine glass of Neuwelt in Bohemia.

Glass tubes, much more fusible than common wine glasses.

Crown glass of Bohemia.

Green glass, for medicinal vials and retorts.

Flask glass of St. Etienne, for which some heavy spar is used.

Glass of Sevres.

London glass employed for chemical and physical purposes.

English flint glass.

Guinand's flint glass.

anufacture of *Glass beads* at Murano near Venice, is most ingeniously simple.

glass of every color are drawn out to great lengths in a gallery adjoining the se pots, in the same way as the more moderate lengths of thermometer and r tubes are drawn in our glass-houses. These tubes are chopped into very small nearly uniform length on the upright edge of a fixed chisel. These elementary being then put in a heap into a mixture of fine sand and wood ashes, are stirred h an iron spatula till their cavities get filled. This curious mixture is now d to an iron pan suspended over a moderate fire and continually stirred about , whereby the cylindrical bits assume a smooth rounded form; so that when re-m the fire and cleared out in the bore, they constitute beads, which are packed and exported in prodigious quantities to almost every country, especially to d Spain.

CUTTING AND GRINDING, for common and optical purposes. By this al process the surface of glass may be modified into almost any ornamental or m.

grinding of crystal ware. This kind of glass is best adapted to receive acets, both on account of its relative softness, and its higher refractive power, es lustre to its surface. The cutting shop should be a spacious long apart-nished with numerous sky-lights, having the grinding and polishing lathes right under them, which are set in motion by a steam-engine or water-wheel at

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one end of the building. A shaft is fixed as usual in gallowses along the ceiling; and from the pulleys of the shaft, bands descend to turn the different lathes, by passing round the driving pulleys near their ends.

The turning lathe is of the simplest construction. *Fig.* 516, D is an iron spindle with two well-turned prolongations, running in the iron puppets *a a*, between two concave bushes of tin or type metal, which may be pressed more or less together by the thumb-screws shown in the figure. These two puppets are made fast to the wooden support B, which is attached by a strong screw and bolt to the al beam of the workshop A. E is the fast and loose pulley for putting the
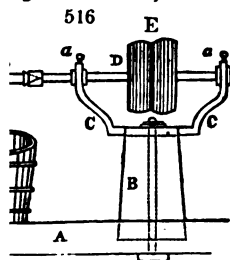
lathe into and out of gear with the driving shaft. The projecting end of the spindle is furnished with a hollow head-piece, into which the rod c is pushed tight. This rod carries the cutting or grinding disc plate. For heavy work, this rod is fixed into the head by a screw. When a conical fit is preferred, the cone is covered with lead to increase the friction.

Upon projecting rods or spindles of that kind the different discs for cutting the glass are made fast. Some of these are made of fine sandstone or polishing slate, from 8 to 10 inches in diameter, and from ⅜ to ½ inch thick. They must be carefully turned and polished at the lathe, not only upon their rounded but upon their flat face, in order to grind and polish in their turn the flat and curved surfaces of glass vessels. Other discs of the same diameter, but only ¼ of an inch thick, are made of cast tin truly turned, and serve for polishing the vessels previously ground; a third set consist of sheet iron from ⅙ to ⅛ an inch thick, and 12 inches in diameter, and are destined to cut grooves in glass by the aid of sand and water. Small discs of well-hammered copper from ¼ to 3 inches in diameter, whose circumference is sometimes flat, and sometimes concave or convex, serve to make all sorts of delineations upon glass by means of emery and oil. Lastly, there are rods of copper or brass furnished with small hemispheres from $\frac{1}{31}$ to ¼ of an inch in diameter, to excavate round hollows in glass. Wooden discs are also employed for polishing, made of white wood cut across the grain, as also of cork.

The cutting of deep indentations, and of grooves, is usually performed by the iron disc, with sand and water, which are allowed constantly to trickle down from a wooden hopper placed right over it, and furnished with a wooden stopple or plug at the apex, to regulate by its greater or less looseness the flow of the grinding materials. The same effect may be produced by using buckets as shown in *fig.* 517. The sand which is contained in the bucket F, above the lathe, has a spigot and faucet inserted near its bottom, and is supplied with a stream of water from the stopcock in the vessel G, which, together running down the inclined board, are conducted to the periphery of the disc as shown in the figure, to whose lowest point the glass vessel is applied with pressure by the hand. The sand and water are afterwards collected in the tub H. Finer markings, which are to remain without lustre, are made with the small copper discs, emery, and oil. The polishing is effected by the edge of the tin disc, which is from time to time moistened with putty (white oxyde of tin) and water. The wooden disc is also employed for this purpose with putty, colcothar, or washed tripoli. For fine delineations, the glass is first traced over with some colored varnish, to guide the hand of the cutter.
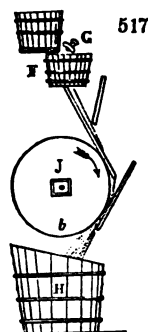
In grinding and facetting crystal glass, the deep grooves are first cut, for example the cross lines, with the iron disc and rounded edge, by means of sand and water. That disc is one sixth of an inch thick and 12 inches in diameter. With another iron disc about half an inch thick, and more or less in diameter, according to the curvature of the surface, the grooves may be widened. These roughly cut parts must be next smoothed down with the sandstone disc and water, and then polished with the wooden disc about half an inch thick, to whose edge the workman applies, from time to time, a bag of fine linen containing some ground pumice moistened with water. When the cork or wooden disc edged with hat felt is used for polishing, putty or colcothar is applied to it. The above several processes in a large manufactory, are usually committed to several workmen on the principle of the division of labor, so that each may become expert in his department.

2. *The grinding of optical glasses.*—The glasses intended for optical purposes, being spherically ground, are called lenses; and are used either as simple magnifiers and spectacles, or for telescopes and microscopes. The curvature is always a portion of a sphere, and either convex or concave. This form ensures the convergence or divergence of the rays of light that pass through them, as the polishing does the brightness of the image.

The grinding of the lenses is performed in brass moulds, either concave or convex, formed to the same curvature as that desired in the lenses; and may be worked either by hand or by machinery. A gauge is first cut out out of brass or copper plate to suit the curvature of the lens, the circular arc being traced by a pair of compasses. In this way both a convex and concave circular gauge are obtained. To these gauges the brass moulds are turned. Sometimes, also, lead moulds are used. After the two moulds are made, they are ground face to face with fine emery.

The piece of glass is now roughed into a circular form by a pair of pincers, leaving it a little larger than the finished lens ought to be, and then smoothed round upon the stone disc, or in an old mould with emery and water, and is next made fast to a hold-fast. This consists of a round brass plate having a screw in its back; and is somewhat smaller in diameter than the lens, and two thirds as thick. This as turned concave upon

the lathe, and then attached to the piece of glass by drops of pitch applied to several points of its surface, taking care, while the pitch is warm, that the centre of the glass coincides with the centre of the brass plate. This serves not merely as a holdfast, by enabling a person to seize its edge with the fingers, but it prevents the glass from bending by the necessary pressure in grinding.

The glass must now be ground with coarse emery upon its appropriate mould, whether convex or concave, the emery being all the time kept moist with water. To prevent the heat of the hand from affecting the glass, a rod for holding the brass plate is screwed to its back. For every six turns of circular motion, it must receive two or three rubs across the diameter in different directions, and so on alternately. The middle point of the glass must never pass beyond the edge of the mould; nor should strong pressure be at any time applied. Whenever the glass has assumed the shape of the mould, and touches it in every point, the coarse emery must be washed away, finer be substituted in its place, and the grinding be continued as before, till all the scratches disappear, and a uniform dead surface be produced. A commencement of polishing is now to be given with pumice stone powder. During all this time the convex mould should be occasionally worked in the concave, in order that both may preserve their correspondence of shape between them. After the one surface has been thus finished, the glass must be turned over, and treated in the same way upon the other side.

Both surfaces are now to be polished. With this view equal parts of pitch and rosin must be melted together, and strained through a cloth to separate all impurities. The concave mould is next to be heated, and covered with that mixture in a fluid state to the thickness uniformly of one quarter of an inch. The cold convex mould is now to be pressed down into the yielding pitch, its surface being quite clean and dry, in order to give the pitch the exact form of the ground lens; and both are to be plunged into cold water till they be chilled. This pitch impression is now the mould upon which the glass is to be polished, according to the methods above described, with finely washed colcothar and water, till the surface become perfectly clear and brilliant. To prevent the pitch from changing its figure by the friction, cross lines must be cut in it about ⅛ an inch asunder, and 1-12th of an inch broad and deep. These grooves remove all the superfluous parts of the polishing powder, and tend to preserve the polishing surface of the pitch clean and unaltered. No additional colcothar after the first is required in this part of the process; but only a drop of water from time to time. The pitch gets warm as the polishing advances, and renders the friction more laborious from the adhesion between the surfaces. No interruption must now be suffered in the work, nor must either water or colcothar be added; but should the pitch become too adhesive, it must be merely breathed upon, till the polish be complete. The nearer the lens is brought to a true and fine surface in the first grinding, the better and more easy does the polishing become. It should never be submitted to this process with any scratches perceptible in it, even when examined by a magnifier.

As to small lenses and spectacle eyes, several are ground and polished together in a mould about 6 inches in diameter, made fast to a stiffening plate of brass or iron of a shape corresponding with the mould. The pieces of glass are affixed by means of drops of pitch, as above described, to the mould, close to each other, and are then all treated as if they formed but one large lens. Plane glasses are ground upon a surface of pitch rendered plane by the pressure of a piece of plate glass upon it in its softened state.

Lenses are also ground and polished by means of machinery, into the details of which the limits of this work will not allow me to enter.

A Return to an Order of the Honorable the House of Commons, dated 1st March, 1838, of the Amount of Duty charged on Glass; distinguishing the Amount charged on Flint, Plate, Broad, Crown, Bottle, and German Sheet, in the Year ending the 5th day of January, 1838; together with the Amount of Drawback on each description of Glass; the produce of the Duties in England, Scotland, and Ireland, stated separately.

	Amount of Duty charged on						
—	Flint Glass.	Plate.	Broad.	Crown.	Bottle.	German Sheet.	Total.
	£ s. d.	£ s.	£ s.	£ s. d.	£ s. d.	£ s.	£ s. d.
England	76,052 1 0	68,902 10	10,789 10	522,404 6 7	122,617 10 2	25,511 17	837,277 14 9
Scotland	7,530 9 4			16,422 11 6	32,246 4 1	—	56,200 4 11
Ireland	6,736 12 11			—	3,642 0 3	—	10,378 13 2
Total	90,319 3 3	68,902 10	10,789 10	549,827 18 1	158,505 14 6	25,511 17	903,856 12 10

Amount of Drawback on Exportation.							
—	Flint Glass.	Plate.	Broad.	Crown.	Bottle.	German Sheet.	Total.
	£ s. d.	£ s. d.	£ s.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
England	15,597 2 7	3,963 17 9	4 10	166,592 10 2	56,770 10 5	23,882 17 0	266,130 0 0
Scotland	1,726 15 5	—	—	6,636 9 0	14,819 9 1	22 15 6	23,205 8 0
Ireland	107 14 5	—	—	10 9 1	274 19 5	—	393 14 2
Total	17,431 12 5	3,963 17 9	4 10	177,569 8 3	71,864 8 11	23,962 13 3	289,736 10 10

The duties payable in the United Kingdom upon the different descriptions of glass are, for—

	£ s. d.
Flint glass, the finished article - - -	- 0 0 2 per lb.
British plate or German sheet, and crown glass, ditto	- 3 13 6 per cwt.
Broad glass, ditto	- 1 10 0 —
Bottles, ditto	- 0 7 0 —
Plate glass, the fused material in pot - -	- 3 0 0 —

GLAZES. See POTTERY.

GLAZIER is the workman who cuts plates or panes of glass, with the diamond, and fastens them by means of putty in frames or window casements. See DIAMOND, for an explanation of its glass-cutting property.

GLAUBER SALT is the old name of sulphate of soda.

GLOVE MANUFACTURE. In February, 1822, Mr. James Winter, of Stoke-under-Hambdon, in the county of Somerset, obtained a patent for an improvement upon a former patent machine of his for sewing and pointing leather gloves. Fig. 518 represents a pedestal, upon which the instrument called the jaws is to be placed. Fig. 519 shows the jaws, which instead of opening and closing by a circular movement upon a joint as described in the former specification, are now made to open and shut by a parallel horizontal movement, effected by a slide and screw; a a is the fixed jaw, made of one piece, on the under side of which is a tenon, to be inserted into the top of the pedestal. By means of this tenon the jaws may be readily removed, and another similar pair of jaws placed in their stead, which affords the advantage of expediting the operation by enabling one person to prepare the work whilst another is sewing; b b is the moveable jaw, made of one piece. The two jaws being placed together in the manner shown at fig. 519, the moveable jaw traverses backwards and forwards upon two guide-bars, c, which are made to pass through holes exactly fitted to them, in the lower parts of the jaws. At the upper parts of the jaws are what are called the indexes, d d, which are pressed tightly together by a spring, shown at fig. 520, and intended to be introduced between the perpendicular ribs of the jaws at e. At f is a thumbscrew, passing through the ribs for the purpose of tightening the jaws, and holding the leather fast between the indexes while being sewn; this screw, however, will seldom, if ever, be necessary if the spring is sufficiently strong; g is an eye or ring fixed to the moveable jaw, through which the end of a lever, h, in fig. 518 passes; this lever is connected by a spring to a treadle, i, at the base of the pedestal, and by the pressure of the right foot upon this treadle, the moveable jaw is withdrawn; so that the person employed in sewing may shift the leather, and place another part of the glove between the jaws. The pieces called indexes are connected to the upper part of the jaws, by screws passing through elongated holes which render them capable of adjustment.

The patentee states, that in addition to the index described in his former patent, which is applicable to what is called round-seam sewing only, and which permits the leather to expand but in one direction when the needle is passed through it, namely, upwards, he

now makes two indexes of different construction, one of which he calls the receding index, and the other the longitudinally grooved index. *Fig.* 521 represents an end view, and *fig.* 522 a top view of the receding index, which is particularly adapted for what are called " drawn sewing, and prick-seam sewing;" this index, instead of biting to the top, is so rounded off in the inside from the bottom of the cross grooves, as to permit the needles, by being passed backwards and forwards, to carry the silk thread on each side of the leather without passing over it. *Fig.* 523 represents an end view of the longitudinally grooved index, partly open, to show the section of the grooves more distinctly; and *fig.* 524 represents an inside view of one side of the same index, in which the longitudinal groove is shown passing from *k* to *l*. This index is more particularly adapted to round seam sewing, and permits the leather to expand in every direction when the needle is passed through it, by which the leather is less strained, and the sewing consequently rendered much stronger.

It is obvious that the parallel horizontal movement may be effected by other mechanical means besides those adopted here, and the chief novelty claimed with respect to that movement, is its application to the purpose of carrying the index used in sewing and pointing leather gloves.

Importation of leather gloves for home consumption; and amount of duty in

1836.	1837.	1836.	1837.
1,461,769.	1,221,350.	£27,558.	£22,923.

GLOVE-SEWING. The following simple and ingenious apparatus, invented by an Englishman, has been employed extensively in Paris, and has enabled its proprietors to realize a handsome fortune. The French complain that " it has inundated the world with gloves, made of excellent quality, at 30 per cent. under their former wholesale
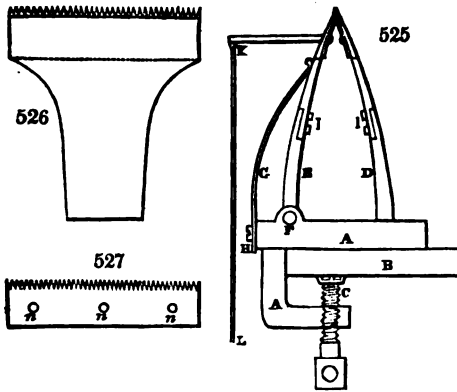
prices." The instrument is shown in profile ready for action in *fig.* 525. It resembles an iron vice, having the upper portion of each jaw made of brass, and tipped with a kind of comb of the same metal. The teeth of this comb, only one twelfth of an inch long, are perfectly regular and equal. Change combs are provided for different styles of work. The vice A A is made fast to the edge of the bench or table B, of the proper height, by a thumb-screw c, armed with a cramp which lays hold of the wood. Of the two jaws composing the machine, the one D is made fast to the foot A A, but the other E is moveable upon the solid base of the machine, by means of a hinge at the point F. At I I is shown how the upper brass portion is adjusted to the lower part made of iron; the two being secured to each other by two stout screws. The comb, seen separately in *fig.* 527, is made fast to the upper end of each jaw, by the three screws n n n. *Fig.* 526 is a front view of the jaw mounted with its comb, to illustrate its construction.

The lever K corresponds by the stout iron wire L, with a pedal pressed by the needle-woman's foot, whenever she wishes to separate the two jaws, in order to insert between them the parallel edges of leather to be sewed. The instant she lifts her foot, the two jaws join by the force of the spring G, which pushes the moveable jaw E against the stationary one D. The spring is made fast to the frame of the vice by the screw H.

After putting the double edge to be sewed in its place, the woman passes her needle successively through all the teeth of the comb, and is sure of making a regular seam in every direction, provided she is careful to make the needle graze along the bottom of the notches. As soon as this piece is sewed, she presses down the pedal with her toes, whereby the jaws start asunder, allowing her to introduce a new seam, and so in quick succession.

The comb may have any desired shape, straight or curved; and the teeth may be larger or smaller, according to the kind of work to be done. With this view, the combs might be changed as occasion requires; but it is more economical to have sets of vices ready mounted with combs of every requisite size and form.

GLUCINA (*Glucine*, Fr.; *Berryllerde*, Germ.) is one of the primitive earths,

originally discovered by Vauquelin, in the beryl and emerald. It may be extracted from either of these minerals, by treating their powder successively with potash, with water, and with muriatic acid. The solution by the latter, being evaporated to dryness, is to be digested with water, and filtered. On pouring carbonate of ammonia in excess into the liquid, we form soluble muriate of ammonia, with insoluble carbonates of lime, chrome, and iron, as also carbonate of glucina, which may be dissolved out from the rest by an excess of carbonate of ammonia. When the liquid is filtered anew, the glucina passes through, and may be precipitated in the state of a carbonate by boiling the liquid, which expels the excess of ammonia. By washing, drying, and calcining the carbonate, pure glucina is obtained. It is a white insipid powder, infusible in the heat of a smith's forge, insoluble in water, but soluble in caustic potash and soda; as also, especially when it is a hydrate, in carbonate of ammonia. It has a metallic base called glucinum, of which 100 parts combine with 45·252 of oxygen to form the earth. It is too rare to be susceptible of application in manufactures.

GLUE (*Colle forte*, Fr.; *Leim, Tischlerleim*, Germ.) is the chemical substance gelatine in a dry state. The preparation and preservation of the skin and other animal matters employed in the manufacture of glue, constitute a peculiar branch of industry. Those who exercise it should study to prevent the fermentation of the substances, and to diminish the cost of carriage by depriving them of as much water as can conveniently be done. They may then be put in preparation by macerating them in milk of lime, renewed three or four times in the course of a fortnight or three weeks. This process is performed in large tanks of masonry. They are next taken out with all the adhering lime, and laid in a layer, 2 or 3 inches thick, to drain and dry, upon a sloping pavement, where they are turned over by prongs, two or three times a day. The action of the lime dissolves the blood and certain soft parts, attacks the epidermis, and disposes the gelatinous matter to dissolve more readily. When the cleansed matters are dried, they may be packed in sacks or hogsheads, and transported to the glue manufactory at any distance. The principal substances of which glue is made are the parings of ox and other thick hides, which form the strongest article; the refuse of the leather dresser; both afford from 45 to 55 per cent. of glue. The tendons, and many other offals of slaughter houses, also afford materials, though of an inferior quality, for the purpose. The refuse of tanneries, such as the ears of oxen, calves, sheep, &c., are better articles; but parings of parchment, old gloves, and, in fact, animal skin, in every form, uncombined with tannin, may be made into glue.

The manufacturer who receives these materials, is generally careful to ensure their purification by subjecting them to a weak lime steep, and rinsing them by exposure in baskets to a stream of water. They are lastly drained upon a sloping surface, as above described, and well turned over till the quicklime gets mild by absorption of carbonic acid; for, in its caustic state, it would damage the glue at the heat of boiling water. It is not necessary, however, to dry them before they are put into the boiler, because they dissolve faster in their soft and tumefied state.

The boiler is made of copper, rather shallow in proportion to its area, with a uniform flat bottom, equably exposed all over to the flame of the fire. Above the true bottom there is a false one of copper or iron, pierced with holes, and standing upon feet 3 or 4 inches high; which serves to sustain the animal matters, and prevent them from being injured by the fire. The copper being filled to two thirds of its height with soft water, is then heaped up with the bulky animal substances, so high as to surmount its brim. But soon after the ebullition begins they sink down, and, in a few hours, get entirely immersed in the liquid. They should be stirred about from time to time, and well pressed down toward the false bottom, while a steady but gentle boil is maintained.

The solution must be drawn off in successive portions; a method which fractions the products, or subdivides them into articles of various value, gradually decreasing from the first portion drawn off to the last. It has been ascertained by careful experiments that gelatine gets altered over the fire very soon after it is dissolved, and it ought therefore to be drawn off whenever it is sufficiently fluid and strong for forming a clear gelatinous mass on cooling, capable of being cut into moderately firm slices by the wire. This point is commonly determined by filling half an egg-shell with the liquor, and exposing it to the air to cool. The jelly ought to get very consistent in the course of a few minutes; if not so, the boiling must be persisted in a little longer. When this term is attained, the fire is smothered up, and the contents of the boiler are left to settle for a quarter of an hour. The stop-cock being partially turned, all the thin gelatinous liquor is run off into a deep boiler, immersed in a warm water bath, so that it may continue hot and fluid for several hours. At the end of this time, the supernatant clear liquid is to be drawn off into congealing boxes, as will be presently explained.

The grounds, or undissolved matters in the boiler, are to be again supplied with a quantity of boiling water from an adjoining copper, and are to be once more subjected to

the action of the fire, till the contents assume the appearance of dissolved jelly, and afford
a fresh quantity of strong glue liquor, by the stop-cock. The grounds should be sub-
jected a third time to this operation, after which they may be put into a bag, and squeezed
in a press to leave nothing unextracted. The latter solutions are usually too weak to
form glue directly, but they may be strengthened by boiling with a portion of fresh
skin-parings.

Fig. 528 represents a convenient apparatus for the boiling of skins into glue, in which

528
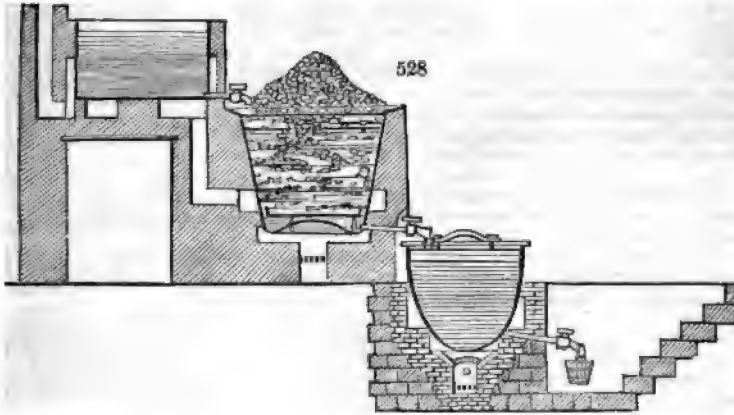
there are three coppers upon three different levels; the uppermost, being acted upon by
the waste heat of the chimney, provides warm water in the most economical way; the
second contains the crude materials, with water for dissolving them; and the third
receives the solution to be settled. The last vessel is double, with water contained
between the outer and inner one; and discharges its contents by a stop-cock into buck-
ets for filling the gelatinizing wooden boxes. The last made solution has about one
five-hundredth part of alum in powder usually added to it, with proper agitation, after
which it is left to settle for several hours.

The three successive boils furnish three different qualities of glue.

Flanders or Dutch glue, long much esteemed on the Continent, was made in the
manner above described, but at two boils, from animal offals well washed and soaked, so
as to need less boiling. The liquor, being drawn off thinner, was therefore less colored,
and being made into thinner plates, was very transparent. The above two boils gave two
qualities of glue.

By the English practice, the whole of the animal matter is brought into solution at once,
and the liquor being drawn off, hot water is poured on the residuum, and made to boil on
it for some time, when the liquor thus obtained is merely used instead of water upon a
fresh quantity of glue materials. The first drawn off liquor is kept hot in a settling cop-
per for five hours, and then the clear solution is drawn off into the boxes.

These boxes are made of deal, of a square form, but a little narrower at bottom than
at top. When very regular cakes of glue are wished for, cross grooves of the desired
square form are cut in the bottom of the box. The liquid glue is poured into the boxes
placed very level, through funnels furnished with filter cloths, till it stands at the brim
of each. The apartment in which this is done ought to be as cool and dry as possible,
to favor the solidification of the glue, and should be floored with stone flags kept very
clean, so that if any glue run through the seams, it may be recovered. At the end of
12 or 18 hours, or usually in the morning if the boxes have been filled over-
night, the glue is sufficiently firm for the nets, and they are at this time removed to
an upper story, mounted with ventilating windows to admit the air from all quarters.
Here the boxes are inverted upon a moistened table, so that the gelatinous cake thus
turned out will not adhere to its surface; usually the moist blade of a long knife is
insinuated round the sides of the boxes beforehand, to loosen the glue. The mass is first
divided into horizontal layers by a brass wire stretched in a frame, like that of a bow-
saw, and guided by rulers which are placed at distances corresponding to the desired
thickness of the cake of glue. The lines formed by the grooves in the bottom of the
box define the superficial area of each cake, where it is to be cut with a moist knife.
The gelatinous layers thus formed must be dexterously lifted, and immediately laid
upon nets stretched in wooden frames, till each frame be filled. These frames are set
over each other at distances of about three inches, being supported by small wooden

pegs, stuck into mortise holes in an upright, fixed round the room; so that the air may have perfectly free access on every side. The cakes must moreover be turned upside down upon the nets twice or thrice every day, which is readily managed, as each frame may be slid out like a drawer, upon the pegs at its two sides.

The drying of the glue is the most precarious part of the manufacture. The least disturbance of the weather may injure the glue during the two or three first days of its exposure; should the temperature of the air rise considerably, the gelatine may turn so soft as to become unshapely, and even to run through the meshes upon the pieces below, or it may get attached to the strings and surround them, so as not to be separable without plunging the net into boiling water. If frost supervene, the water may freeze and form numerous cracks in the cakes. Such pieces must be immediately re-melted and re-formed. A slight fog even produces upon glue newly exposed a serious deterioration; the damp condensed upon its surface occasioning a general mouldiness. A thunderstorm sometimes destroys the coagulating power in the whole laminæ at once; or causes the glue to *turn* on the nets, in the language of the manufacturer. A wind too dry or too hot may cause it to dry so quickly, as to prevent it from contracting to its proper size without numerous cracks and fissures. In this predicament, the closing of all the flaps of the windows is the only means of abating the mischief. On these accounts it is of importance to select the most temperate season of the year, such as spring and autumn, for the glue manufacture.

After the glue is dried upon the nets it may still preserve too much flexibility, or softness at least, to be saleable; in which case it must be dried in a stove by artificial heat. This aid is peculiarly requisite in a humid climate, like that of Great Britain.

When sufficiently dry it next receives a gloss, by being dipped cake by cake in hot water, and then rubbed with a brush also moistened in hot water; after which the glue is arranged upon a hurdle, and transferred to the stove room, if the weather be not sufficiently hot. One day of proper drought will make it ready for being packed up in casks.

The pale-colored, hard, and solid article, possessing a brilliant fracture, which is made from the parings of ox-hides by the first process, is the best and most cohesive, and is most suitable for joiners, cabinet-makers, painters, &c. But many workmen are influenced by such ignorant prejudices, that they still prefer a dark-colored article, with somewhat of a fetid odor, indicative of its impurity and bad preparation, the result of bad materials and too long exposure to the boiling heat.

There is a good deal of glue made in France from bones, freed from the phosphate of lime by muriatic acid. This is a poor article, possessing little cohesive force. It dissolves almost entirely in cold water, which is the best criterion of its imperfection. Glue should merely soften in cold water, and the more considerably it swells, the better, generally speaking, it is.

Some manufacturers prefer a brass to a copper pan for boiling glue, and insist much on skimming it as it boils; but the apparatus I have represented renders skimming of little consequence. For use, glue should be broken into small pieces, put along with some water into a vessel, allowed to soak for some hours, and subjected to the heat of a boiling-water bath, but not boiled itself. The surrounding hot water keeps it long in a fit state for joiners, cabinet-makers, &c.

Water containing only one hundredth part of good glue, forms a tremulous solid. When the solution, however, is heated and cooled several times, it loses the property of gelatinizing, even though it be enclosed in a vessel hermetically sealed. Isinglass or fish-glue undergoes the same change. Common glue is not soluble in alcohol, but is precipitated in a white, coherent, elastic mass, when its watery solution is treated with that fluid. By transmitting chlorine gas through a warm solution of glue a combination is very readily effected, and a viscid mass is obtained like that thrown down by alcohol. A little chlorine suffices to precipitate the whole of the glue. Concentrated sulphuric acid makes glue undergo remarkable changes; during which are produced, sugar of gelatine, leucine, an animal matter, &c. Nitric acid, with the aid of heat, converts glue into malic acid, oxalic acid, a fat analogous to suet, and into tannin; so that, in this way, one piece of skin may be made to tan another. When the mixture of glue and nitric acid is much evaporated, a detonation at last takes place. Strong acetic acid renders glue first soft and transparent, and then dissolves it. Though the solution does not gelatinize, it preserves the property of gluing surfaces together when it dries. Liquid glue dissolves a considerable quantity of lime, and also of the phosphate of lime recently precipitated. Accordingly glue is sometimes contaminated with that salt. Tannin both natural and artificial combines with glue; and with such effect, that one part of glue dissolved in 5000 parts of water affords a sensible precipitate with the infusion of nutgalls. Tannin unites with glue in several proportions, which are to each other as the numbers 1, 1½, and 2; one compound consists of 100 glue and 89 tannin; another of 100 glue and 60 tannin; and a third of 100 glue and 120 tannin. These two sub-

not be afterwards separated from each other by any known chemical

be freed from the foreign animal matters generally present in it, by soft-
old water, washing it with the same several times till it no longer gives out
en bruising it with the hand, and suspending it in a linen bag beneath the
large quantity of water at 60° F. In this case, the water loaded with the
rities of the glue gradually sinks to the bottom of the vessel, while the pure
i in the bag surrounded with water. If this softened glue be heated to 92°
ng water, it will liquefy; and if we heat it to 122°, and filter it, some albu-
)ther impurities will remain on the filter, while a colorless solution of glue
·ough.
its have not yet explained how gelatine is formed from skin by ebullition.
e somewhat analogous to that of starch into gum and sugar, and takes place
appreciable disengagement of gas, and even in close vessels. Gelatine, says
)es not exist in the living body, but several animal tissues, such as skin,
irtshorn, tendons, the serous membranes, and bones, are susceptible of being
:o it.

(*Colle Vegetale*, Fr.; *Kleber*, Germ.) was first extracted by Beccaria from
and was long regarded as a proximate principle of plants, till Einhof, Tad-
:elius succeeded in showing that it may be resolved by means of alcohol into
it substances, one of which resembles closely animal albumine, and has been
me, or vegetable albumine; another has been called *Gliadine*; and a third,
ie mode of separating gluten from the other constituents of wheat flour has
ed towards the end of the article BREAD.
ien dried in the air or a stove, diminishes greatly in size, becomes hard, brit-
g, and of a deep yellow color. It is insoluble in ether, in fat, and essential
rly so in water. Alcohol and acetic acid cause gluten to swell and make a
·solution. Dilute acids and alkaline leys dissolve gluten. Its ultimate con-
not determined, but azote is one of them, and accordingly when moist gluten
nent, it exhales the smell of old cheese.
INE is a sweet substance which may be extracted from fatty substances.
qual parts of olive oil and finely-ground litharge, put them into a basin with
·, set this on a sand bath moderately heated, and stir the mixture constantly,
asional addition of hot water to replace what is lost by evaporation, we shall
hort time a soap or plaster of lead. After having added more water to this,
ie vessel from the fire, decant the liquor, filter it, pass sulphureted hydrogen
i separate the lead, then filter afresh, and concentrate the liquor as much as
ithout burning upon the sand bath. What remains must be finally evapora-
e receiver of the air-pump. Glycerine thus prepared is a transparent liquid,
: or smell, and of a sirupy consistence. It has a very sweet taste. Its spe-
is 1·27 at the temperature of 60°. When thrown upon burning coals, it
i burns like an oil. Water combines with it in almost all proportions; alco-
it readily; nitric acid converts it into oxalic acid; and according to Vogel,
d transforms it into sugar, in the same way as it does starch. Ferment or
it affect it in any degree.
ients are, carbon, 40; hydrogen, 9; oxygen, 51; in 100.
i the name of one of the great mountain formations, being reckoned the
stratified rocks. It is composed of the same substances as granite, viz.:
. and feldspar. In gneiss, however, they are not in granular crystals, but in
to give the mass a slaty structure. It abounds in metallic treasures.
ng. and Germ.; *Or*, Fr.). This metal is distinguished by its splendid.
; its great density = 19·3, compared to water 1·0; its fusibility at the
of Wedgewood's pyrometer; its pre-eminent ductility and malleability,
in be beat into leaves only one 282,000th of an inch thick; and its insolu-
acid menstruum, except the mixture of muriatic and nitric acids, styled
mists *aqua regia*, because gold was deemed by them to be the king of

ind only in the metallic state, sometimes crystallized in the cube, and its de
s. It occurs also in threads of various size, twisted and interlaced into a chain
tahedral crystals; as also in spangles or roundish grains, which, when of a
itude, are called *pepitas*. The small grains are not fragments broken from
is; but they show by their flattened ovoid shape, and their rounded outline,
ieir original state. The spec. grav. of native gold varies from 13·3 to 17·7.
ites that the largest *pepita* known was one found in Peru, weighing about
ies (26½ lbs. avoird.); but masses have been quoted in the province of
weighed nearly four times as much.
·e of gold is the alloy with silver, or argental gold, the electrum of Pliny,

so called from its amber shade. It seems to be a definite compound, containing in 100 parts, 64 of gold and 36 of silver.

The mineral formations in which this metal occurs, are the crystalline primitive rocks, the compact transition rocks, the trachytic and trap rocks, and alluvial grounds.

It never predominates to such a degree as to constitute veins by itself. It is either disseminated, and as it were impasted in stony masses, or spread out in thin plates or grains on their surface, or, lastly, implanted in their cavities, under the shape of filaments or crystallised twigs. The minerals composing the veins are either quartz, calcspar, or sulphate of baryta. The ores that accompany the gold in these veins are chiefly iron pyrites, copper pyrites, galena, blende, and mispickel (arsenical pyrites).

In the ores called auriferous pyrites, this metal occurs either in a visible or invisible form, and though invisible in the fresh pyrites, becomes visible by its decomposition; as the hydrated oxyde of iron allows the native gold particles to shine forth on their reddish-brown ground, even when the precious metal may constitute only the five millionth part of its weight, as at Rammelsberg in the Hartz. In that state it has been extracted with profit; most frequently by amalgamation with mercury, proving that the gold was in the native state, and not in that of a sulphuret.

Gold exists among the primitive strata, disseminated in small grains, spangles, and crystals. Brazil affords a remarkable example of this species of gold mine. Beds of granular quartz, or micaceous specular iron, in the Sierra of Cocães, 12 leagues beyond Villa Rica, which form a portion of a mica-slate district, include a great quantity of native gold in spangles, which in this ferruginous rock replace mica.

Gold has never been observed in any secondary formation, but pretty abundantly in its true and primary locality among the trap rocks of igneous origin; implanted on the sides of the fissures, or disseminated in the veins.

The auriferous ores of Hungary and Transylvania, composed of tellurium, silver pyrites or sulphuret of silver, and native gold, lie in masses or powerful veins in a rock of trachyte, or in a decomposed feldspar subordinate to it. Such is the locality of the gold ore of Königsberg, of Telkebanya, between Eperies and Tokay in Hungary, and probably that of the gold ores of Kapnick, Felsobanya, &c., in Transylvania; an arrangement nearly the same with what occurs in Equatorial America. The auriferous veins of Guanaxuato, of Real del Monte, of Villalpando, are similar to those of Schemnitz in Hungary, as to magnitude, relative position, the nature of the ores they include, and of the rocks they traverse. These districts have impressed all mineralogists with the evidences of the action of volcanic fire. Breislak and Hacquet have described the gold mines of Transylvania as situated in the crater of an ancient volcano. It is certain that the trachytes which form the principal portions of the rocks including gold, are now almost universally regarded as of igneous or volcanic origin.

It would seem, however, that the primary source of the gold is not in these rocks, but rather in the sienites and greenstone porphyries below them, which in Hungary and Transylvania are rich in great auriferous deposites; for gold has never been found in the trachyte of the Euganean mountains, of the mountains of the Vicentin, of those of Auvergne; all of which are superposed upon granite rocks, barren in metal.

Finally, if it be true that the ancients worked mines of gold in the island of Ischia, it would be another example, and a very remarkable one, of the presence of this metal in trachytes of an origin evidently volcanic.

Gold is, however, much more common in the alluvial grounds than among the primitive and pyrogenous rocks just described. It is found disseminated under the form of spangles, in the silicious, argillaceous, and ferruginous sands of certain plains and rivers, especially in their re-entering angles, at the season of low water, and after storms and temporary floods.

It has been supposed that the gold found in the beds of rivers had been torn out by the waters from the veins and primitive rocks, which they traverse. Some have even searched, but in vain, at the source of auriferous streams, for the native bed of this precious metal. The gold in them belongs, however, to the grounds washed by the waters as they glide along. This opinion, suggested at first by Delius, and supported by Deborn, Guettard, Robitant, Balbo, &c., is founded upon just observations. 1. The soil of these plains contains, frequently, at a certain depth and in several spots, spangles of gold, separable by washing. 2. The beds of the auriferous rivers and streamlets contain more gold after storms of rain upon the plains than in any other circumstances. 3. It happens almost always that gold is found among the sands of rivers only in a very circumscribed space; on ascending these rivers their sands cease to afford gold; though did this metal come from the rocks above, it should be found more abundantly near the source of the rivers. Thus it is known that the Oreo contains no gold except from Pont to its junction with the Po. The Ticino affords gold only below the Lago Maggiore, and consequently far from the primitive mountains, after traversing a lake, where its course is slackened, and into which whatsoever it carried down from these mountains

must have been deposited. The Rhine gives more gold near Strasburg than near Basle, though the latter be much closer to the mountains. The sands of the Danube do not contain a grain of gold, while this river runs in a mountainous region; that is, from the frontiers of the bishopric of Passau to Efferding; but its sands become auriferous in the plains below. The same thing is true of the Ems; the sands of the upper portion of this river, as it flows among the mountains of Styria, include no gold; but from its entrance into the plain at Steyer, till its embouchure in the Danube, its sands become auriferous, and are even rich enough to be washed with profit.

The greater part of the auriferous sands, in Europe, Asia, Africa, and America, are black or red, and consequently ferruginous; a remarkable circumstance in the geological position of alluvial gold. M. Napione supposes that the gold of these ferruginous grounds is due to the decomposition of auriferous pyrites. The auriferous sand occurring in Hungary almost always in the neighborhood of the beds of lignites, and the petrified wood covered with gold grains, found buried at a depth of 55 yards in clay, in the mine of Vorospatak near Abrabanya in Transylvania, might lead us to presume that the epoch of the formation of the auriferous alluvia is not remote from that of the lignites. The same association of gold ore and fossil wood occurs in South America, at Moco. Near the village of Lloro, have been discovered at a depth of 20 feet, large trunks of petrified trees, surrounded with fragments of trap rocks interspersed with spangles of gold and platinum. But the alluvial soil affords likewise all the characters of the basaltic rocks; thus in France, the Cèze and the Gardon, auriferous rivers, where they afford most gold, flow over ground apparently derived from the destruction of the trap rocks, which occur in situ higher up the country. This fact had struck Reaumur, and this celebrated observer had remarked that the sand which more immediately accompanies the gold spangles in most rivers, and particularly in the Rhone and the Rhine, is composed, like that of Ceylon and Expailly, of black protoxyde of iron and small grains of rubies, corindon, hyacinth, &c. Titanium has been observed more recently. It has, lastly, been remarked that the gold of alluvial formations is purer than that extracted from rocks.

Principal Gold Mines.

Spain anciently possessed mines of gold in regular veins, especially in the province of Asturias; but the richness of the American mines has made them to be neglected. The Tagus, and some other streams of that country, were said to roll over golden sands. France contains no workable gold mines; but it presents in several of its rivers auriferous sands. There are some gold mines in Piedmont; particularly the veins of auriferous pyrites of Macugnagna, at the foot of Monte Rosa, lying in a mountain of gneiss; and although they do not contain 10 or 11 grains of gold in a hundred weight, they have long defrayed the expense of working them. On the southern slope of the Pennine Alps, from the Simplon and Monte Rosa to the valley of Aoste, several auriferous districts and rivers occur. Such are the torrent Evenson, which has afforded much gold by washing; the Oreo, in its passage from the Pont to the Po; the reddish grounds over which this little river runs for several miles, and the hills in the neighborhood of Chivasso, contain gold spangles in considerable quantity.

In the county of Wicklow, in Ireland, a quartzose and ferruginous sand was discovered not long ago, containing many particles of gold, with pepitas or solid pieces, one of which weighed 22 ounces. No less than 1000 ounces of gold were collected.

There are auriferous sands in some rivers of Switzerland, as the Reuss and the Aar. In Germany no mine of gold is worked, except in the territory of Salzburg, amid the chain of mountains which separates the Tyrol and Carinthia.

The mines of Hungary and Transylvania are the only gold mines of any importance in Europe; they are remarkable for their position, the peculiar metals that accompany them, and their product, estimated at about 1430 pounds avoird. annually. The principal ones are in Hungary. 1. Those of Konigsberg. The native gold is disseminated in ores of sulphuret of silver, which occur in small masses and in veins in a decomposing feldspar rock, amid a conglomerate of pumice, constituting a portion of the trachytic formation. 2. Those of Borson, Schemnitz. And, 3. of Felsobanya; ores also of auriferous sulphuret of silver, occur in veins of sienite and greenstone porphyry. 4. Those of Telkebanya, to the south of Kaschau, are in a deposite of auriferous pyrites amid trap rocks of the most recent formation.

In Transylvania the gold mines occur in veins often of great magnitude, 6, 8, and sometimes 40 yards thick. These veins have no side plates or wall stones, but abut without intermediate gangues at the primitive rock. They consist of carious quartz, ferriferous limestone, heavy spar, fluor spar, and sulphuret of silver. The mine of Kapnik deserves notice, where the gold is associated with orpiment, and that of Vorospatak in granite rocks; those of Offenbanya, Zalatna, and Nagy-Ag, where it is associated with tellurium. The last is in a sienitic rock on the limits of the trachyte.

In Sweden, the mine of Edelfors in Smoland may be mentioned, where the gold occurs native and in auriferous pyrites; the veins are a brown quartz, in a mountain of foliated hornstone.

In Siberia, native gold occurs in a hornstone at Schlangenberg or Zmeof, and at Zmeino-garsk in the Altai mountains, accompanied with many other ores.

The gold mine of Berezof in the Oural mountains has been long known, consisting of *partially decomposed auriferous pyrites*, disseminated in a vein of greasy quartz. About 1820, a very rich deposite of native gold was discovered upon the eastern side of the Oural mountains, disseminated at some yards depth, in an argillaceous loam, and accompanied with the *débris* of rocks which usually compose the auriferous alluvial soils, as green-stone, serpentine, protoxyde of iron, corundum, &c. The rivers of this district possess auriferous sands. The annual product of the gold mines of Siberia is 3740 pounds avoirdupois.

In Asia, and especially in its southern districts, there are many mines, streams, rivers, and wastes, which contain this metal. The Pactolus, a small river of Lydia, rolled over such golden sands, that it was supposed to constitute the origin of the wealth of Crœsus. But these deposites are now poor and forgotten. Japan, Formosa, Ceylon, Java, Sumatra, Borneo, the Philippines, and some other islands of the Indian Archipelago, are supposed to be very rich in gold mines. Those of Borneo are worked by the Chinese in an alluvial soil on the western coast, at the foot of a chain of volcanic mountains.

Little or no gold comes into Europe from Asia, because its servile inhabitants place their fortune in treasure, and love to hoard up that precious metal.

Numerous gold mines occur on the two slopes of the chain of the Cailas mountains in the Oundès, a province of Little Thibet. The gold lies in quartz veins which traverse a very crumbling reddish granite.

Africa was, with Spain, the source of the greater portion of the gold possessed by the ancients. The gold which Africa still brings into the market in abundance is always in dust, showing that the metal is obtained by washing the alluvial soils. None of it is collected in the north of that continent; three or four districts only are remarkable for the quantity of gold they produce.

The first mines are those of Kordofan, between Darfour and Abyssinia. The negroes transport the gold in quills of the ostrich or vulture. These mines seem to have been known to the ancients, who considered Ethiopia to abound in gold. Herodotus relates that the king of that country exhibited to the ambassadors of Cambyses, all their prison-ers bound with golden chains.

The second and chief exploitation of gold dust is to the south of the great desert of Zaara, in the western part of Africa, from the mouth of the Senegal to the Cape of Palms. The gold occurs in spangles, chiefly near the surface of the earth, in the bed of rivulets, and always in a ferruginous earth. In some places the negroes dig wells in the soil to a depth of about 40 feet, unsupported by any props. They do not follow any vein; nor do they construct a gallery. By repeated washings they separate the gold from the earthy matters.

The same district furnishes also the greater part of what is carried to Morocco, Fez, and Algiers, by the caravans which go from Timbuctoo on the Niger, across the great desert of Zaara. The gold which arrives by Senna at Cairo and Alexandria, comes from the same quarter. From Mungo Park's description, it appears that the gold spangles are found usually in a ferruginous small gravel, buried under rolled pebbles.

The third spot in Africa where gold is collected, is on the south-east coast, between the twenty-fifth and the twenty-second degree of south latitude, opposite to Madagascar, in the country of Sofala. Some persons think that this was the kingdom of Ophir, whence Solomon obtained his gold.

In modern times, the richest gold mines are found in America, from which there is exported annually, 3700 or 4000 pounds avoirdupois of this metal. It occurs there principally in spangles among the alluvial earths, and in the beds of rivers; more rarely in veins.

There is little gold in the northern part of America. The United States have hitherto produced but a slight quantity of alluvial gold, collected in the gravel pits of the creeks of Rockhole, district of Lebanon, in North Carolina. In 1810, a mass was found there, weighing 28 pounds. This district has furnished the mint of the United States with about 100 lbs. avoirdupois of gold.

South America, especially Brazil, Choco, and Chili, are the regions which furnish most gold.

The gold of Mexico is in a great measure contained in the argentiferous veins, so numerous in that country, whose principal localities are mentioned under the article SILVER. The silver of the argentiferous ores of Guanaxato, contains one 360th of its weight of gold; the annual product of the mines being valued at from 2640 to 3300 pounds avoirdupois.

Oaxaco contains the only auriferous veins exploited as gold mines in Mexico; they traverse rocks of gneiss and mica slate.

All the rivers of the province of Caraccas, to ten degrees north of the line, flow over golden sands.

Peru is not rich in gold ores. In the provinces of Huailas and Pataz, this metal is mined in veins of greasy quartz, variegated with red ferruginous spots, which traverse primitive rocks. The mines called *pacos de oro*, consist of ores of iron and copper oxydes, containing a great quantity of gold.

All the gold furnished by New Grenada (New Colombia) is the product of washings, established in alluvial grounds. The gold exists in spangles and in grains, disseminated among fragments of greenstone and porphyry. At Choco, along with the gold and platinum, hyacinths, zircons, and titanium occur. There have been found, as already stated, in the auriferous localities, large trunks of petrified trees. The gold of Antioquia is 20 carats fine, that of Choco 21, and the largest lump or *pepita* of gold weighed about 27½ pounds avoirdupois. The gold of Chili also occurs in alluvial formations.

Brazil furnishes the greatest part of the gold now brought into the market. Yet there is not in this country any gold mine properly ⁸ⁿ called; for the veins containing the metal are seldom worked.

It is in the sands of the Mandi, a branch of the Rio-Dolce, at Catapreta, that the auriferous ferruginous sands were first discovered in 1682. Since then, they have been found almost everywhere at the foot of the immense chain of mountains, which runs nearly parallel with the coast, from the 5th degree south to the 30th. It is particularly near Villa Rica, in the environs of the village Cocães, that the numerous washings for gold are established. The *pepitas* occur in different forms, often adhering to micaceous specular iron. But in the province of Minas Geräes, the gold occurs also in veins, in beds, and in grains, disseminated among the alluvial loams. It has been estimated in annual product, by several authors, at about 2800 pounds avoirdupois of fine metal; worth nearly a million sterling.

We thus see that almost all the gold brought into the market, comes from alluvial lands, and is extracted by washing.

The gold coin of the ancients was made chiefly out of alluvial gold, for in these early times the metallurgic arts were not sufficiently advanced to enable them to purify it. The gold dust from Bambouk in Africa, is of 22¼ carats fine, and some from Morocco is even 23.

The gold of Giron, in New Grenada, is of 23⅔ carats; being the purest from America. " For those who traffic in gold," says Humboldt, " it is sufficient to learn the place where the metal has been collected, to know its title."

Metallurgic treatment of gold.—The gold found in the sands of rivers, or in auriferous soils, needs not be subjected to any metallurgic process, properly speaking. The Orpaillers separate it from the sands, by washing them first upon inclined tables, sometimes covered with a cloth, and then by hand in wooden bowls of a particular form. Amalgamation is employed to carry off from the sand the minuter particles of gold they may contain. The people called Bohemians, Cigans, or Tehinganes, who wash the auriferous sands in Hungary, employ a plank with 24 transverse grooves cut in its surface. They hold this plank in an inclined position, and put the sand to be washed in the first groove; they then throw water on it, when the gold mixed with a little sand collects usually towards the lowest furrow. They remove this mixture into a flat wooden basin, and by a peculiar sleight of hand, separate the gold entirely from the sand. The richest of the auriferous ores consist of the native gold quite visible, disseminated in a gangue, but the veins are seldom continuous for any length. The other ores are auriferous metallic sulphurets, such as sulphurets of copper, silver, arsenic, &c., and particularly iron.

The stony ores are first ground in the stamping mill, and then washed in hand-basins, or on wooden tables.

The auriferous sulphurets are much more common, but much poorer than the former ores; some contain only one 200,000th part of gold, and yet they may be worked with advantage, when treated with skill and economy.

The gold of these ores is separated by two different processes; namely, by fusion and amalgamation.

The auriferous metallic sulphurets are first roasted; then melted into *mattes*, which are roasted anew; next fused with lead, whence an auriferous lead is obtained, which may be refined by the process of cupellation.

When the gold ores are very rich, they are melted directly with lead, without preliminary calcination or fusion. These processes are, however, little practised, because they are less economical and certain than amalgamation, especially when the gold ores are very poor.

If these ores consist of copper pyrites, and if their treatment has been pushed to the point

of obtaining auriferous rose copper, or even black copper including gold, the precious metal cannot be separated by the process of liquation, because the gold, having more affinity for copper than for lead, can be but partially run off by the latter metal. For these reasons the process of amalgamation is far preferable.

This process being the same for silver, I shall reserve its description for this metal. The rich ores in which the native gold is apparent, and merely disseminated in a stony gangue, are directly triturated with quicksilver, without any preparatory operation. As to the poor ores, in which the gold seems lost amid a great mass of iron, sulphuret of copper, &c., they are subjected to a roasting before being amalgamated. This process seems requisite to lay bare the gold enveloped in the sulphurets. The quicksilver with which the ore is now ground, seizes the whole of its gold, in however small quantity this metal may be present.

The gold procured by the refining process with lead, is free from copper and lead, but it may contain iron, tin, or silver. It cannot be separated from iron and tin without great difficulty and expense, if the proportion of gold be too small to admit of the employment of muriatic acid.

By cupellation with lead, gold may be deprived of any antimony united with it.

Tin gives gold a remarkable hardness and brittleness; a piece of gold, exposed for some time over a bath of red hot tin, becomes brittle. The same thing happens more readily over antimony, from the volatility of this metal. A two thousandth part of antimony, bismuth, or lead, destroys the ductility of gold. The tin may be got rid of by throwing some corrosive sublimate or nitre into a crucible, containing the melted alloy. By the first agent, perchloride of tin is volatilised; by the second, stannate of potash forms, which is carried off in the resulting alkaline scoriæ.

Gold treated by the process of amalgamation, contains commonly nothing but a little silver. The silver is dissolved out by nitric acid, which leaves the gold untouched; but to make this parting with success and economy on the great scale, several precautions must be observed.

If the gold do not contain fully two thirds of its weight of silver, this metal, being thoroughly enveloped by the gold, is partially screened from the action of the acid. Whenever, therefore, it is known by a trial on a small scale, that the silver is much below this proportion, we must bring the alloy of gold and silver to that standard by adding the requisite quantity of the latter metal. This process is called quartation.

This alloy is then granulated or laminated; and from twice to thrice its weight of sulphuric or nitric acid is to be boiled upon it; and when it is judged that the solution has been pushed as far as possible by this first acid, it is decanted, and new acid is poured on. Lastly, after having washed the gold, some sulphuric acid is to be boiled over it, which carries off a two or three thousandth part of silver, which nitric acid alone could not dissolve. Thus perfectly pure gold is obtained.

The silver held in solution by the sulphuric or nitric acid is precipitated in the metallic state by copper, or in the state of chloride by sea-salt. See PARTING.

Not only has the ratio between the value of gold and silver varied much in different ages of the world; but the ratio between these metals and the commodities they represent has undergone variations, owing to the circumstances in which their mines have been successively placed; since they have always poured a greater quantity of the metals into the market than has been absorbed by use. This quantity has greatly increased since the discovery of America, a period of little more than 300 years. The mines of that continent, rich, numerous, and easily worked, by augmenting the mass of gold and silver, necessarily lessened the value of these metals compared with that of the objects of commerce represented by them, so that everything else being equal, there is now required for purchasing the same quantity of commodities, much more gold or silver than was necessary in the reign of Henry VII., before the discovery of America. This productiveness of the American mines has had an influence on those of the ancient continent; many of whose silver and gold mines have been abandoned, not because the veins or auriferous sands are less rich than they were, but because their product no longer represents the value of human labor, and of the goods to be furnished in return for their exploitation.

In the 3d vol. of the Mining Journal, p. 331, we have the following statement as to the produce of the precious metals.—"In 40 years, from 1790 to 1830, Mexico produced 6,436,453*l.* worth of gold, and 139,818,032*l.* of silver. Chili, 2,768,488*l.* of gold, and 1,822,924*l.* of silver. Buenos Ayres, 4,024,895*l.* of gold, and 27,182,673*l.* of silver. Russia, 3,703,743*l.* of gold, and 1,502,981*l.* of silver. Total, 1880 millions sterling, or 47 millions per annum.

The following table shows what proportion the product of the mines of America bears to that of the mines of the ancient continent.

Table of the Quantities of Gold which may be considered as having been brought into the European Market, every Year on an Average, from 1790 to 1802.

Continents.	Gold.
ANCIENT CONTINENT.	lbs. Avoir.
Asia : - - - - - -	
Siberia - - - - - -	3740
Africa - - - - - - -	3300
Europe : - - - - - -	
Hungary - - - ᵻ -	1430
Salzbourg ·: - - - -	165
Austrian States - - - - -	
Haitz and Hessia - - - -	
Saxony - - - - - -	
Norway - - - - - -	165
Sweden - - - - - -	
France - - - - - -	
Spain, &c. - - - - - -	
Total of the Ancient Continent - -	8800
NEW CONTINENT.	
North America - - - - - -	2860
South America - - - - - -	
Spanish dominions - - - -	22,000
Brazil - - - - - -	15,400
Total of the New Continent - - -	40,260

The mines of America have sent into Europe three and a half times more gold, and twelve times more silver, than those of the ancient continent. The total quantity of silver was to that of gold in the ratio of 55 to 1; a very different ratio from that which holds really in the value of these two metals, which is in Europe as 1 to 15. This difference depends upon several causes, which cannot be investigated here at length; but it may be stated that gold, by its rarity and price, being much less employed in the arts than silver, the demand for it is also much less; and this cause is sufficient to lower its price much beneath what it would have been, if it had followed the ratio of its quantity compared to that of silver. Thus also bismuth, tin, &c., though much rarer than silver, are, nevertheless, very inferior in price to it. Before the discovery of America, the value of gold was not so distant from that of silver, because since that era silver has been distributed in Europe in a far greater proportion than gold. In Asia the proportion is now actually only 1 to 11 or 12; the product of the gold mines in that quarter, being not so much below that of the silver mines as in the rest of the world.

The total annual production of Gold at present has been estimated as follows.

From the ancient Spanish colonies of America - - - 10,400 kilogrammes
    Brazil - - - - - - - - - 600
    Europe and Asiatic Russia - - - - - 6,200
    The Indian Archipelago - - - - - - 4,700
    Africa - - - - - - - - - 14,000 ?

35,900 = 36 tons nearly

without taking into account the quantity of gold now extracted from silver.

Gold has less affinity for oxygen than any other metal. When alone, it cannot be oxydized by any degree of heat with contact of air, although in combination with other oxydized bodies, it may pass into the state of an oxyde, and be even vitrified. The purple smoke into which gold leaf is converted by an electric discharge is not an oxyde, for it is equally formed when the discharge is made through it in hydrogen gas. There are two oxydes of gold; the first or protoxyde is a green powder, which may be obtained by pouring, in the cold, a solution of potash into a solution of the metallic chloride. It is not durable, but soon changes in the menstruum into metallic gold,

and peroxyde. Its constituents are 96·13 metal, and 3·87 oxygen. The peroxyde is best prepared by adding magnesia to a solution of the metallic chloride; washing the precipitate with water till this no longer takes a yellow tint from muriatic acid; then digesting strong nitric acid upon the residuum, which removes the magnesia, and leaves the peroxyde in the form of a black or dark brown powder, which seems to partake more of the properties of a metallic acid than a base.   It contains 10·77 per cent. of oxygen. For the curious combination of gold and tin, called the Purple Precipitate of Cassius, see this article, and Pigments Vitrifiable.

Gold beating.—This is the art of reducing gold to extremely thin leaves, by beating with a hammer.   The processes employed for this purpose may be applied to other metals, as silver, platinum, and copper.   Under tin, zinc, &c., we shall mention such modifications of the processes as these metals require to reduce them to thin leaves. The Romans used to gild the ceilings and walls of their apartments; and Pliny tells us, that from an ounce of gold forming a plate of 4 fingers square, about 600 leaves of the same area were hammered.   At the present day, a piece of gold is extended so as to cover a space 651,590 times greater than its primary surface when cast.

The gold employed in this art ought to be of the finest standard.   Alloy hardens gold, and renders it less malleable; so that the fraudulent tradesman who should attempt to debase the gold, would expose himself to much greater loss in the operations, than he could derive of profit from the alloy.

Four principal operations constitute the art of gold beating.   1. The casting of the gold ingots. 2. The hammering.   3. The lamination; and 4, the beating.

1. The gold is melted in a crucible along with a little borax.   When it has become liquid enough, it is poured out into the ingot-moulds previously heated, and greased on the inside.   The ingot is taken out and annealed in hot ashes, which both soften it and free it from grease.   The moulds are made of cast iron, with a somewhat concave internal surface, to compensate for the greater contraction of the central parts of the metal in cooling than the edges.   The ingots weigh about 2 ounces each, and are ⅜ of an inch broad.

2. *The forging.*—When the ingot is cold, the French gold-beaters hammer it out on a mass of steel 4 inches long and 3 broad.   The hammer for this purpose is called the forging hammer.   It weighs about 3 pounds, with a head at one end and a wedge at the other, the head presenting a square face of 1½ inches.   Its handle is 6 inches long.   The workman reduces the ingot to the thickness of ⅙ of an inch at most; and during this operation he anneals it whenever its substance becomes hard and apt to crack.   The English gold-beaters omit this process of hammering.

3. *The lamination.*—The rollers employed for this purpose should be of a most perfectly cylindrical figure, a polished surface, and so powerful as not to bend or yield in the operation.   The ultimate excellence of the gold leaf depends very much on the precision with which the riband is extended in the rolling press.   The laminating machine represented under the article Mint, is an excellent pattern for this purpose.   The gold-beater desires to have a riband of such thinness that a square inch of it will weigh 6½ grains. Frequent annealings are requisite during the lamination.

4. *Beating.*—The riband of gold being thus prepared uniform, the gold-beater cuts it with shears into small squares of an inch each, having previously divided it with compasses, so that the pieces may be of as equal weight as possible.   These squares are piled over each other in parcels of 150, with a piece of fine calf-skin vellum interposed between each, and about 20 extra vellums at the top and bottom.   These vellum leaves are about 4 inches square, on whose centre lie the gold laminæ of an inch square.   This packet is kept together by being thrust into a case of strong parchment open at the ends, so as to form a belt or band, whose open sides are covered in by a second case drawn over the packet at right angles to the first.   Thus the packet becomes. sufficiently compact to bear beating with a hammer of 15 or 16 pounds weight, having a circular face nearly 4 inches diameter, and somewhat convex, whereby it strikes the centre of the packet most forcibly, and thus squeezes out the plates laterally.

The beating is performed on a very strong bench or stool framed to receive a heavy block of marble, about 9 inches square on the surface, enclosed upon every side by woodwork, except the front where a leather apron is attached, which the workman lays before him to preserve any fragments of gold that may fall out of the packet.   The hammer is short-handled, and is managed by the workman with one hand; who strikes fairly on the middle of the packet, frequently turning it over to beat both sides alike; a feat dexterously done in the interval of two strokes, so as not to lose a blow.   The packet is occasionally bent or rolled between the hands, to loosen the leaves and secure the ready extension of the gold; or it is taken to pieces to examine the gold, and to shift the central leaves to the outside, and vice versa, that every thing may be equalized.   Whenever the gold plates have extended, under this treatment, to nearly the size of the vellum, they are removed from the packet, and cut into four equal squares by a knife. They

iced to nearly the same size as at first, and are again made up into packets
as before, with this difference, that skins prepared from ox-gut are now
?tween each gold leaf instead of vellum. The second course of beating is
ith a smaller hammer, about 10 pounds in weight, and is continued till the
tended to the size of the skins. During this period the packet must be often
ider the gold as loose as possible between the membranes; otherwise the
.sily chafed and broken. They are once more spread on a cushion, and sub-
four square pieces by means of two pieces of cane cut to very sharp edges,
vn transversely on a board. This rectangular cross being applied on each
ght pressure, divides it into four equal portions. These are next made up into
:t of convenient thickness, and finally hammered out to the area of fine gold
.verage size is from 3 to 3½ inches square. The leaves will now have ob-
:a 192 times greater than the plates before the hammering begun. As these
lly an inch square, and 75 of them weighed an ounce (= 6½ × 75 = 487½),
f the finished leaves will be 192 × 75 = 14,400 square inches, or 100 square
ce troy. This is by no means the ultimate degree of attenuation, for an
e hammered so as to cover 160 square feet; but the waste incident in this
e number of broken leaves, and the increase and nicety of the labor, make
·ofitable refinement; while the gilder finds such thin leaves to make less
satisfactory work.
ed leaves of gold are put up in small books made of single leaves of soft
d over with red chalk to prevent adhesion between them. Before putting
. these books, however, they are lifted one by one with a delicate pair of pin-
ie finishing packet, and spread out on a leather cushion by blowing them flat
y are then cut to one size, by a sharp-edge square moulding of cane, glued
rd. When this square-framed edge is pressed upon the gold, it cuts it to the
ind shape. Each book commonly contains 25 gold leaves.
w describe some peculiarities of the French practice of gold beating. The
ts the laminated ribands of an inch broad into portions an inch and a half
? are called *quartiers*. He takes 24 of them, which he places exactly over
o as to form a thickness of about an inch, the riband being ⅓ of a line, or
h thick; and he beats them together on the steel slab with the round face
he hammer, so as to stretch them truly out into the square form. He begins
the substance towards the edges, thereafter advancing towards the middle;
as much on the other side, and finally hammers the centre. By repeating
beating as often as necessary, he reduces at once all the *quartiers* (squares)
packet, till none of them is thicker than a leaf of gray paper, and of the
are of 2 inches each side.
quartiers are brought to this state, the workman takes 56 of them, which
·each other, and with which he forms the first packet (*caucher*) in the man-
lescribed; only two leaves of vellum are interposed between each gold leaf.
eaves of vellum at the top and bottom of the packet are called *emplures*.
nches square, as well as the parchment pieces.
et thus prepared forms a rectangular parallelopiped; it is enclosed in two
posed each of several leaves of parchment applied to each, and glued at the
rming a bag open at either end.
of black marble is a foot square at top, and 18 inches deep, and is framed
scribed. The hammer used for beating the first packet is called the flat,
ing hammer; its head is round, about 5 inches in diameter, and very slightly
is 6 inches high, and tapers gradually from its head to the other extremity,
it the form of a hexagonal truncated pyramid. It weighs 14 or 15

:h gold-beaters employ, besides this hammer, three others of the same form;
The *commencing hammer*, which weighs 6 or 7 pounds, has a head 4 inches
and is more convex than the former. 2. The *spreading hammer (marteau*
its head is two inches diameter, more convex than the last, and weighs only
s. 3. The *finishing hammer;* it weighs 12 or 13 pounds, has a head four
ter, and is the most convex of all.
ig processes do not differ essentially from the English described above. The
ibed over with fine calcined Paris plaster, with a hare's foot. The skin of
ter is a pellicle separated from the outer surface of ox-gut; but before
·ed for this purpose, it must undergo two preparations. 1. It is sweated, in
:l any grease it may contain. With this view, each piece of membrane is
:en two leaves of white paper; several of these pairs are piled over each
ruck strongly with a hammer, which drives the grease from the gut into the

is given to the pieces of gut; that is, they are moistened with an infusion

of cinnamon, nutmeg, and other warm and aromatic ingredients, in order to preserve them; an operation repeated after they have been dried in the air. When the leaves of skin are dry, they are put in a press, and are now ready for use. After the parchment, vellum, and gut membrane have been a good deal hammered, they become unfit for work, till they are restored to proper flexibility, by being placed leaf by leaf between leaves of white paper, moistened sometimes with vinegar, at others with white wine. They are left in this predicament for 3 or 4 hours, under compression of a plank loaded with weights. When they have imbibed the proper humidity, they are put between leaves of parchment 12 inches square, and beat in that situation for a whole day. They are then rubbed over with fine calcined gypsum, as the vellum was originally. The gut-skin is apt to contract damp in standing, and is therefore dried before being used.

The average thickness of common gold leaf is $\frac{1}{282000}$ of an inch.

The art of Gilding.—This art consists in covering bodies with a thin coat of gold; which may be done either by mechanical or chemical means. The mechanical mode is the application of gold leaf or gold powder to various surfaces, and their fixation by various means. Thus gold may be applied to wood, plaster, pasteboard, leather; and to metals, such as silver, copper, iron, tin, and bronze; so that gilding, generally speaking, includes several arts, exercised by very different classes of tradesmen.

I. *Mechanical Gilding.*—Oil gilding is the first method under this head, as oil is the fluid most generally used in the operation of this mechanical art. The following process has been much extolled at Paris.

1. A coat of *impression* is to be given first of all, namely, a coat of white lead paint, made with drying linseed oil, containing very little oil of turpentine.

2. Calcined ceruse is to be ground very well with unboiled linseed oil, and tempered with essence of turpentine, in proportion as it is laid on. Three or four coats of this *hard tint* are to be applied evenly and dryly on the ornaments and the parts which are to be most carefully gilded.

3. The *Gold color* is then to be smoothly applied. This is merely the dregs of the colors, ground and tempered with oil, which remain in the little dish in which painters clean their brushes. This substance is extremely rich and gluey; after being ground up, and passed through fine linen cloth, it forms the ground for gold leaf.

4. When the gold color is dry enough to catch hold of the leaf gold, this is spread on the cushion, cut into pieces, and carefully applied with the palette knife, pressed down with cotton, and in the small ornaments with a fine brush.

5. If the gildings be for outside exposure, as balconies, gratings, statues, &c., they must not be varnished, as simple oil gilding stands better; for when it is varnished, a bright sun-beam, acting after heavy rain, gives the gilding a jagged appearance. When the objects are inside ones, a coat of spirit varnish may be passed over the gold leaf, then a glow from the gilder's chafing dish may be given, and finally a coat of oil varnish. The workman who causes the chafing dish to glide in front of the varnished surface, must avoid stopping for an instant opposite any point, otherwise he would cause the varnish to boil and blister. This heat brings out the whole transparency of the varnish and lustre of the gold.

Oil Gilding is employed, with varnish polish, upon equipages, mirror-frames, and other furniture. The following method is employed by eminent gilders at Paris.

1. White lead, with half its weight of yellow ochre, and a little litharge, are separately ground very fine; and the whole is then tempered with linseed oil, thinned with essence of turpentine, and applied in an evenly coat, called *impression*.

2. When this coat is quite dry, several coats of the hard tint are given, even so many as 10 or 12, should the surface require it, for smoothing and filling up the pores. These coats are given daily, leaving them to dry in the interval in a warm sunny exposure.

3. When the work is perfectly dry, it is first softened down with pumice stone and water, afterwards with worsted cloth and very finely powdered pumice, till the *hard tint* give no reflection, and be smooth as glass.

4. With a camel's hair brush, there must be given lightly and with a gentle heat, from 4 to 5 coats at least, and even sometimes double that number, of fine lac varnish.

5. When these are dry, the grounds of the panels and the sculptures must be first polished with shave-grass (*de la prèle*); and next with putty of tin and tripoli, tempered with water, applied with woollen cloth; by which the varnish is polished till it shines like a mirror.

6. The work thus polished is carried into a hot place, free from dust, where it receives very lightly and smoothly a thin coat of *gold color*, much softened down. This coat is passed over it with a clean soft brush, and the thinner it is the better.

7. Whenever the gold color is dry enough to take the gold, which is known by laying the back of the hand on a corner of the frame work, the gilding is begun and finished as usual.

8. The gold is smoothed off with a very soft brush, one of camel's hair, for example, of three fingers' breadth; after which it is left to dry for several days.

9. It is then varnished with a spirit of wine varnish; which is treated with the chafing dish as above described.

10. When this varnish is dry, two or three coats of copal or oil varnish are applied, at intervals of two days.

11. Finally, the panels are polished with a worsted cloth, imbued with tripoli and water, and lustre is given by friction with the palm of the hand, previously softened with a little olive oil, taking care not to rub off the gold.

In this country, *burnished gilding* is practised by first giving a ground of size whiting, in several successive coats; next applying gilding size; and then the gold leaf, which is burnished down with agate, or a dog's tooth.

Gilding in distemper of the French, is the same as our burnished gilding. Their process seems to be very elaborate, and the best consists of 17 operations; each of them said to be essential.

1. *Encollage*, or the *glue coat*. To a decoction of wormwood and garlic in water, strained through a cloth, a little common salt and some vinegar are added. This composition, as being destructive of worms in wood, is mixed with as much good glue; and the mixture is spread in a hot state, with a brush of boar's hair. When plaster or marble is to be gilded, the salt must be left out of the above composition, as it is apt to attract humidity in damp places, and to come out as a white powder on the gilding. But the salt is indispensable for wood. The first glue coating is made thinner than the second.

2. *White preparation.* This consists in covering the above surface with 8, 10, or 12 coats of Spanish white, mixed up with strong size, each well worked on with the brush, and in some measure incorporated with the preceding coat, to prevent their peeling off in scales.

3. *Stopping up* the pores, with thick whiting and glue, and smoothing the surface with dog-skin.

4. Polishing the surface with pumice-stone and very cold water.

5. *Reparation;* in which a skilful artist retouches the whole.

6. *Cleansing;* with a damp linen rag, and then a soft sponge.

7. *Prêler.* This is rubbing with horse's tail (*shave-grass*) the parts to be yellowed, in order to make them softer.

8. *Yellowing.* With this view *yellow ochre* is carefully ground in water, and mixed with transparent colorless size. The thinner part of this mixture is applied hot over the white surface with a fine brush, which gives it a fine yellow hue.

9. *Ungraining* consists in rubbing the whole work with shave-grass, to remove any granular appearance.

10. *Coat of assiette; trencher coat.* This is the composition on which the gold is to be laid. It is composed of Armenian bole, 1 pound; bloodstone (hematite), 2 ounces; and as much galena; each separately ground in water. The whole are then mixed together, and ground up with about a spoonful of olive oil. The *assiette* well made and applied gives beauty to the gilding. The *assiette* is tempered with a white sheep-skin glue, very clear and well strained. This mixture is heated and applied in three successive coats, with a very fine long-haired brush.

11. *Rubbing*, with a piece of dry, clean linen cloth; except the parts to be burnished, which are to receive other two coats of *assiette* tempered with glue.

12. *Gilding.* The surface, being damped with cold water (iced in summer), has then the gold leaf applied to it. The hollow grounds must always be gilded before the prominent parts. Water is dexterously applied by a soft brush, immediately behind the gold leaf, before laying it down, which makes it lie smoother. Any excess of water is then removed with a dry brush.

13. *Burnishing* with bloodstone.

14. *Deadening.* This consists in passing a thin coat of glue, slightly warmed, over the parts that are not to be burnished.

15. *Mending;* that is, moistening any broken points with a brush, and applying bits of gold leaf to them.

16. The *vermeil* coat. Vermeil is a liquid which gives lustre and fire to the gold; and makes it resemble *or moulu*. It is composed as follows: 2 ounces of annotto, 1 ounce of gamboge, 1 ounce of vermilion, half an ounce of dragon's blood, 2 ounces of salt of tartar, and 18 grains of saffron, are boiled in a litre (2 pints English) of water, over a slow fire, till the liquid be reduced to a fourth. The whole is then passed through a silk or muslin sieve. A little of this is made to glide lightly over the gold, with a very soft brush.

17. *Repassage* is passing over the dead surfaces a second coat of deadening glue, which must be hotter than the first. This finishes the work, and gives it strength.

Leaf gilding, on paper or vellum, is done by giving them a coat of gum water or fine size, applying the gold leaf ere the surfaces be hard dry, and burnishing with agate.

Gold lettering, on bound books, is given without size, by laying the gold leaf on the leather, and imprinting it with hot brass types.

The *edges of the leaves of books are gilded* while they are in the press, where they have been cut smooth, by applying a solution of isinglass in spirits, and laying on the gold when the edges are in a proper state of dryness. The French workmen employ a ground of Armenian bole, mixed with powdered sugar-candy, by means of white of egg. This ground is laid very thin upon the edges, after fine size or gum water has been applied; and when the ground is dry it is rubbed smooth with a wet rag, which moistens it sufficiently to take the gold.

Japanner's gilding is done by sprinkling or daubing with wash leather, some gold powder, over an oil sized surface, mixed with oil of turpentine. This gives the appearance of frosted gold. The gold powder may be obtained, either by precipitating gold from its solution in *aqua regia* by a solution of pure sulphate of iron, or by evaporating away the mercury from some gold amalgam.

II. *Chemical gilding*, or the application of gold by chemical affinity to metallic surfaces.

A compound of copper with one seventh of brass is the best metal for gilding on; copper by itself being too soft and dark colored. Ordinary brass, however, answers very well. We shall describe the process of wash gilding, with M. D'Arcet's late improvements, now generally adopted in Paris.

Wash gilding consists in applying evenly an amalgam of gold to the surface of a copper alloy, and dissipating the mercury with heat, so as to leave the gold film fixed. The surface is afterwards burnished or deadened at pleasure. The gold ought to be quite pure, and laminated to facilitate its combination with the mercury; which should also be pure.

Preparation of the amalgam. After weighing the fine gold, the workman puts it in a crucible, and as soon as this becomes faintly red, he pours in the requisite quantity of mercury; which is about 8 to 1 of gold. He stirs up the mixture with an iron rod, bent hookwise at the end, leaving the crucible on the fire till he perceives that all the gold is dissolved. He then pours the amalgam into a small earthen dish containing water, washes it with care, and squeezes out of it with his fingers all the running mercury that he can. The amalgam that now remains on the sloping sides of the vessel is so pasty as to preserve the impression of the fingers. When this is squeezed in a shamoy leather bag, it gives up much mercury; and remains an amalgam, consisting of about 33 of mercury, and 57 of gold, in 100 parts. The mercury which passes through the bag, under the pressure of the fingers, holds a good deal of gold in solution; and is employed in making fresh amalgam.

Preparation of the mercurial solution. The amalgam of gold is applied to brass, through the intervention of pure nitric acid, holding in solution a little mercury.

100 parts of mercury, and 110 parts by weight of pure nitric acid, specific gravity 1·33, are to be put into a glass matrass. On the application of a gentle heat the mercury dissolves with the disengagement of fumes of nitrous gas, which must be allowed to escape into the chimney. This solution is to be diluted with about 25 times its weight of pure water, and bottled up for use.

1. *Annealing.*—The workman anneals the piece of bronze after it has come out of the hands of the turner and engraver. He sets it among burning charcoal, or rather peats, which have a more equal and lively flame; covering it quite up, so that it may be oxydized as little as possible, and taking care that the thin parts of the piece do not become hotter than the thicker. This operation is done in a dark room, and when he sees the piece of a cherry red color, he removes the fuel from about it, lifts it out with long tongs, and sets it to cool slowly in the air.

2. The *decapage.*—The object of this process is to clear the surface from the coat of oxyde which may have formed upon it. The piece is plunged into a bucket filled with extremely dilute sulphuric acid; it is left there long enough to allow the coat of oxyde to be dissolved, or at least loosened; and it is then rubbed with a hard brush. When the piece becomes perfectly bright, it is washed and dried. Its surface may however be still a little variegated; and the piece is therefore dipped in nitric acid, specific gravity 1·33, and afterwards rubbed with a long-haired brush. The addition of a little common salt to the dilute sulphuric acid would probably save the use of nitric acid, which is so apt to produce a new coat of oxyde. It is finally made quite dry (after washing in pure water), by being rubbed well with tanners' dry bark, saw-dust, or bran. The surface should now appear somewhat de-polished; for when it is very smooth, the gold does not adhere so well.

Application of the amalgam.—The gilder's *scratch-brush* or pencil, made with fine brass wire, is to be dipped into the solution of nitrate of mercury, and is then to be drawn over a lump of gold amalgam, laid on the sloping side of an earthen vessel, after which it is to be applied to the surface of the brass. This process is to be

repeated, dipping the brush into the solution, and drawing it over the amalgam, till the whole surface to be gilded is coated with its just proportion of gold. The piece is then washed in a body of water, dried, and put to the fire to volatilize the mercury. If one coat of gilding be insufficient, the piece is washed over anew with amalgam, and the operation recommenced till the work prove satisfactory.

4. *Volatilization of the mercury.*—Whenever the piece is well coated with amalgam, the gilder exposes it to glowing charcoal, turning it about, and heating it by degrees to the proper point; he then withdraws it from the fire, lifts it with long pincers, and, seizing it in his left hand, protected by a stuffed glove, he turns it over in every direction, rubbing and striking it all the while with a long-haired brush, in order to equalize the amalgam. He now restores the piece to the fire, and treats it in the same way till the mercury be entirely volatilized, which he recognises by the hissing sound of a drop of water let fall on it. During this time he repairs the defective spots, taking care to volatilize the mercury very slowly. The piece, when thoroughly coated with gold, is washed, and scrubbed well with a brush in water acidulated with vinegar.

If the piece is to have some parts burnished, and others dead, the parts to be burnished are covered with a mixture of Spanish white, bruised sugar-candy, and gum dissolved in water. This operation is called in French *epargner* (*protecting*). When the gilder has *protected* the burnished points, he dries the piece, and carries the heat high enough to expel the little mercury which might still remain on it. He then plunges it, while still a little hot, in water acidulated with sulphuric acid, washes it, dries it, and gives it the burnish.

5. The *burnish* is given by rubbing the piece with burnishers of hematite (bloodstone). The workman dips his burnisher in water sharpened with vinegar, and rubs the piece always in the same direction backwards and forwards, till it exhibits a fine polish, and a complete metallic lustre. He then washes it in cold water, dries it with fine linen cloth, and concludes the operation by drying it slowly on a grating placed above a chafing dish of burning charcoal.

6. The *deadening* is given as follows. The piece, covered with the *protection* on those parts that are to be burnished, is attached with an iron wire to the end of an iron rod, and is heated strongly so as to give a brown hue to the *epargne* by its partial carbonization. The gilded piece assumes thus a fine tint of gold; and is next coated over with a mixture of sea salt, nitre, and alum, fused in the water of crystallization of the latter salt. The piece is now restored to the fire, and heated till the saline crust which covers it becomes homogeneous, nearly transparent, and enters into true fusion. It is then taken from the fire and suddenly plunged into cold water, which separates the saline crust, carrying away even the coat of *epargne*. The piece is lastly passed through very weak nitric acid, washed in a great body of water, and dried by exposure either to the air, over a drying stove, or with clean linen cloths.

7. *Of or-moulu color.* — When it is desired to put a piece of gilded bronze into *or-moulu* color, it must be less scrubbed with the scratch-brush than usual, and made to *come back again* by heating it more strongly than if it were to be deadened, and allowing it then to cool a little. The *or-moulu* coloring is a mixture of hematite, alum, and sea salt. This mixture is to be thinned with vinegar, and applied with a brush so as to cover the gilded brass, with reserve of the burnished parts. The piece is then put on glowing coals, urged a little by the bellows, and allowed to heat till the color begins to blacken. The piece ought to be so hot that water sprinkled on it may cause a hissing noise. It is then taken from the fire, plunged into cold water, washed, and next rubbed with a brush dipped in vinegar, if the piece be smooth, but if it be chased, weak nitric acid must be used. In either case, it must be finally washed in a body of pure water, and dried over a gentle fire.

8. *Of red gold color.*—To give this hue, the piece, after being coated with amalgam and heated, is in this hot state to be suspended by an iron wire, and tempered with the composition known under the name of gilder's wax; made with yellow wax, red ochre, verdigris, and alum. In this state it is presented to the flame of a wood fire, is heated strongly, and the combustion of its coating is favored by throwing some drops of the wax mixture into the burning fuel. It is now turned round and round over the fire, so that the flame may act equally. When all the wax of the coloring is burned away, and when the flame is extinguished, the piece is to be plunged in water, washed, and scrubbed with the scratch-brush and pure vinegar. If the color is not beautiful, and quite equal in shade, the piece is coated with verdigris dissolved in vinegar, dried over a gentle fire, plunged in water, and scrubbed with pure vinegar, or even with a little weak nitric acid if the piece exhibit too dark a hue. It is now washed, burnished, washed anew, wiped with linen cloth, and finally dried over a gentle fire.

The following is the outline of a complete gilding factory, as now fitted up at Paris.

Fig. 529. Front elevation and plan of a complete gilding workshop.

P. Furnace of appel, or draught, serving at the same time to heat the deadening pan (pollon au mat).

529
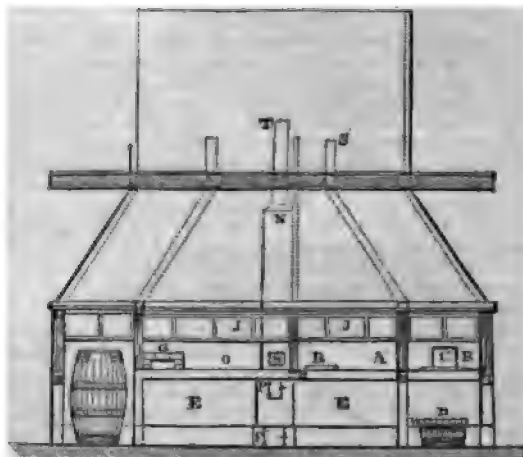
F. Ashpit of this furnace.

N. Chimney of this furnace constructed of bricks, as far as the contraction of the great chimney s of the forge, and which is terminated by a summit pipe rising 2 or 3 yards above this contraction.

B. Forge for annealing the pieces of bronze; for drying the gilded pieces, &c.

C. Chimney of communication between the annealing forge B, and the space D below the forge. This chimney serves to carry the noxious fumes into the great vent of the factory.

U. Bucket for the brightening operation.

A. Forge for passing the amalgam over the piece.

R. Shelf for the brushing operations.

E E. Coal cellarets.

O. Forge for the deadening process.

G. Furnace for the same.

M. An opening into the furnace of *appel*, by which vapors may be let off from any operation by taking out the plug at M.

I. Cask in which the pieces of gilded brass are plunged for the deadening process. The vapors rising thence are carried up the general chimney.

J J. Casement with glass panes, which serves to contract the opening of the hearths, without obstructing the view. The casement may be rendered moveable to admit larger objects.

H H. Curtains of coarse cotton cloth, for closing at pleasure, in whole or part, one or several of the forges or hearths, and for quickening the current of air in the places where the curtains are not drawn.

Q. Opening above the draught furnace, which serves for the heating of the *pollon au mat* (deadening pan).

Gilding on polished iron and steel.—If a nearly neutral solution of gold in muriatic acid be mixed with sulphuric ether, and agitated, the ether will take up the gold, and float above the denser acid. When this auriferous ether is applied by a hair pencil to brightly polished iron or steel, the ether flies off, and the gold adheres. It must be fixed by polishing with the burnisher. This gilding is not very rich or durable. In fact, the affinity between gold and iron is feeble, compared to that between gold and copper or silver. But polished iron, steel, and copper, may be gilded with heat, by gold leaf. They are first heated till the iron takes a bluish tint, and till the copper has attained to a like temperature; a first coat of gold leaf is now applied, which is pressed gently

down with a burnisher, and then exposed to a gentle heat. Several leaves either single
or double are thus applied in succession, and the last is burnished down cold.

Cold gilding.—Sixty grains of fine gold and 12 of rose copper are to be dissolved in
two ounces of aqua regia. When the solution is completed, it is to be dropped on clean
linen rags, of such bulk as to absorb all the liquid. They are then dried, and burned in-
to ashes. These ashes contain the gold in powder.

When a piece is to be gilded, after subjecting it to the preliminary operations of soft-
ening or annealing and brightening, it is rubbed with a moistened cork, dipped in the
above powder, till the surface seems to be sufficiently gilded. Large works are there-
after burnished with pieces of hematite, and small ones with steel burnishers, along with
soap water. '

In gilding small articles, as buttons, with amalgam, a portion of this is taken equivalent
to the work to be done, and some nitrate of mercury solution is added to it in a wooden
trough; the whole articles are now put in, and well worked about with a hard brush, till
their surfaces are equably coated. They are then washed, dried, and put altogether into
an iron frying-pan, and heated till the mercury begins to fly off, when they are turned out
into a cap, in which they are tossed and well stirred about with a painter's brush. The
operation must be repeated several times for a strong gilding. The surfaces are finally
brightened by brushing them along with small beer or ale grounds.

Gold wire is formed by drawing a cylindrical rod of the metal, as pure as may be,
through a series of holes punched in an iron plate, diminishing progressively in size. The
gold, as it is drawn through, becomes hardened by the operation, and requires frequent
annealing.

Gold thread, or *spun gold*, is a flatted silver-gilt wire, wrapped or laid over a thread of
yellow silk, by twisting with a wheel and iron bobbins. By the aid of a mechanism like
the Braiding Machine, a number of threads may thus be twisted at once by one master
wheel. The principal nicety consists in so regulating the movements that the successive
volutions of the flatted wire on each thread may just touch one another, and form a
continuous covering. The French silver for gilding is said to be alloyed with 5 or 6
pennyweights, and ours with 12 pennyweights of copper in the pound troy. The gold
is applied in leaves of greater or less thickness, according to the quality of the gilt wire.
The smallest proportion formerly allowed in this country by act of parliament, was 100
grains of gold to one pound, or 5760 grains of silver; but more or less may now be used.
The silver rod is encased in the gold leaf, and the compound cylinder is then drawn into
round wire down to a certain size, which is afterwards flatted in a rolling mill such as is
described under MINT.

The liquor employed by goldsmiths to bring out a rich color upon the surface of their
trinkets, is made by dissolving 1 part of sea salt, 1 part of alum, 2 parts of nitre, in 3 or
4 of water. This pickle or sauce, as it is called, takes up not only the copper alloy, but
a notable quantity of gold; the total amount of which in the Austrian empire, has been
estimated annually at 47,000 francs. To recover this gold, the liquor is diluted with at
least twice its bulk of boiling water; and a solution of very pure green sulphate of iron
is poured into it. The precipitate of gold is washed upon a filter, dried, and purified by
melting in a crucible along with a mixture of equal parts of nitre and borax.

GONG-GONG, or *tam-tam* of the Chinese; a kind of cymbal made of a copper alloy,
described towards the end of the article COPPER.

GONIOMETER is the name of a little instrument made either on mechanical or
optical principles, for measuring the angles of crystals. It is indispensable to the mine-
ralogist.

GRADUATOR, called by its contriver, M. Wagenmann, *Essigbilder*, which means
in German, vinegar-maker, is represented in *fig.* 530. It is
an oaken tub, 5¼ feet high, 3½ feet wide at top, and 3 at
bottom, set upon wooden beams, which raise its bottom
about 14 inches from the floor. At a distance of 15 inches
above the bottom, the tub is pierced with a horizontal row
of 8 equidistant round holes, of an inch in diameter. At 5
inches beneath the mouth of the tub, a thick beech-wood
hoop is made fast to the inner surface, which supports a
circular oaken shelf, leaving a space round its edge of 1¾
inches, which is stuffed water tight with hemp or tow. In
this shelf, 400 holes at least must be bored, about ½ of an
inch in diameter and 1½ inches apart; and each of these
must be loosely filled with a piece of packthread; or cotton
wick, which serves to filter the liquid slowly downwards.

In the same shelf there are likewise four larger holes of 1½ inches diameter, and 18
inches apart, each of which receives air-tight a glass tube 3 or 4 inches long, having its
ends projecting above and below the shelf. These tubes serve to allow the air that
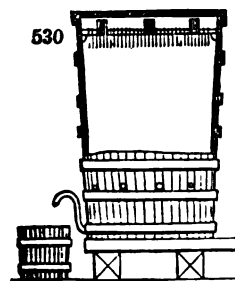
enters by the 8 circumferential holes, to circulate freely through the graduator. The mouth of the tube is covered with a wooden lid, in whose middle is a hole for the insertion of a funnel, when the liquor of acetification requires to be introduced.   One inch above the bottom, a hole is bored for receiving a syphon-formed discharge pipe, whose upper curvature stands one inch below the level of the holes in the side of the tub, to prevent the liquor from rising so high as to overflow through them.   The syphon is so bent as to retain a body of liquor 12 inches deep above the bottom of the tub, and to allow the excess only to escape into the subjacent receiver.   In the upper part of the graduator, but under the shelf, the bulb of a thermometer is inserted through the side, some way into the interior, having a scale exteriorly.   The whole capacity of the cask from the bottom up to within one inch of the perforated shelf, is to be filled with thin shavings of beech wood, grape stalks, or birch twigs, previously imbued with vinegar.   The manner of using this simple apparatus is described under ACETIC ACID.

GRANITE is a compound rock, essentially composed of quartz, feldspar, and mica, each in granular crystals.   It constitutes the lowest of the geological formations, and therefore has been supposed to serve as a base to all the rest.   It is the most durable material for building, as many of the ancient Egyptian monuments testify.

The obelisk in the place of Saint Jean de Lateran at Rome, which was quarried at Syene, under the reign of Zetus, king of Thebes, 1300 years before the Christian era; and the one in the place of Saint Pierre, also at Rome, consecrated to the Sun by a son of Sesostris, have resisted the weather for fully 3000 years.   On the other hand there are many granites, especially those in which feldspar predominates, which crack and crumble down in the course of a few years.   In the same mountain, or even in the same quarry, granites of very different qualities as to soundness and durability occur.   Some of the granites of Cornwall and Limousin readily resolve themselves into a white kaolin or argillaceous matter, from which pottery and porcelain are made.

Granite, when some time dug out of the quarry, becomes refractory, and difficult to cut. When this rock is intended to be worked it should be kept under water ; and that variety ought to be selected which contains least feldspar, and in which the quartz or gray crystals predominate.

GRANULATION is the process by which metals are reduced to minute grains.   It is effected by pouring them, in a melted state, through an iron cullender pierced with small holes, into a body of water; or directly upon a bundle of twigs immersed in water.   In this way copper is granulated into bean shot, and silver alloys are granulated preparatory to PARTING ; which see.

GRAPHITE (*Plombagine*,Fr.; *Reissblei*, Germ.) is a mineral substance of a lead or iron gray color, a metallic lustre, soft to the touch, and staining the fingers with a lead gray hue.   Spec. grav. 2·08 to 2·45.   It is easily scratched, or cut with a steel edge, and displays the metallic lustre in its interior.   Burns with great difficulty in the outward flame of the blow-pipe.   It consists of carbon in a peculiar state of aggregation, with an extremely minute and apparently accidental impregnation of iron.   Graphite, called also plumbago and black lead, occurs in gneiss, mica slate, and their subordinate clay slates and lime stones ; in the form of masses, veins, and kidney-shaped disseminated pieces; as also in the transition slate, as at Borrodale in Cumberland, where the most precious deposite exists, both in reference to extent and quality, for making pencils.   It has been found also among the coal strata, as near Cumnock in Ayrshire.   This substance is employed for counteracting friction between rubbing surfaces of wood or metal, for making crucibles and portable furnaces, for giving a gloss to the surface of cast iron, &c.   See PLUMBAGO, for some remarks concerning the Cumberland mine.

GRAUWACKE, or GREYWACKE, is a rock formation, composed of pieces of quartz, flinty slate, feldspar, and clay slate, cemented by a clay-slate basis ; the pieces varying in size from small grains to a hen's egg.

GRAY DYE.   (*Teinture grise*, Fr.; *Graufärbe*, Germ.)   The gray dyes, in their numerous shades, are merely various tints of black, in a more or less diluted state, from the deepest to the lightest hue.

The dyeing materials are essentially the tannic and gallic acid of galls or other astringents, along with the sulphate or acetate of iron, and occasionally wine stone. Ash gray is given for 30 pounds of woollen stuff, by one pound of gall-nuts, ¼ lb. of wine stone (crude tartar), and 2¼ lbs. of sulphate of iron.   The galls and the wine stone being boiled with from 70 to 80 pounds of water, the stuff is to be turned through the decoction at a boiling heat for half an hour, then taken out, when the bath being refreshed with cold water, the copperas is to be added, and, as soon as it is dissolved, the stuff is to be put in and fully dyed.   Or, for 36 pounds of wool; 2 pounds of tartar, ½ pound of galls, 3 pounds of sumach, and 2 pounds of sulphate of iron are to be taken.   The tartar being dissolved in 80 pounds of boiling water, the wool is to be turned through the solution for half an hour, and then taken out.   The copper being filled up to its former level with fresh water, the decoction of the galls and sumach is to

be poured in, and the wool boiled for half an hour in the bath. The wool is then taken out, while the copperas is being added and dissolved; after which it is replaced in the bath, and dyed gray with a gentle heat.

If the gray is to have a yellow cast, instead of the tartar, its own weight of alum is to be taken; instead of the galls, one pound of old fustic; instead of the copperas, ⅔ of a pound of Saltzburg vitriol, which consists, in 22⅔ parts, of 17 of sulphate of iron, and 5⅔ of sulphate of copper; then proceed as above directed. Or the stuff may be first stained in a bath of fustic, next in a weak bath of galls with a little alum; then the wool being taken out, a little vitriol (common or Saltzburg) is to be put in, previously dissolved in a decoction of logwood; and in this bath the dye is completed.

Pearl gray is produced by passing the stuff first through a decoction of sumach and logwood (2 lbs. of the former to one of the latter), afterwards through a dilute solution of sulphate or acetate of iron; and finishing it in a weak bath of weld containing a little alum. *Mouse-gray* is obtained, when with the same proportions as for ash-gray, a small quantity of alum is introduced.

For several other shades, as tawny-gray, iron-gray, and slate-gray, the stuff must receive a previous blue ground by dipping it in the indigo vat; then it is passed first through a boiling bath of sumach with galls, and lastly through the same bath at a lower temperature after it has received the proper quantity of solution of iron.

For dyeing silk gray, fustet, logwood, sumach, and elder-tree bark, are employed instead of galls. Archil and annotto are frequently used to soften and beautify the tint.

The mode of producing gray dyes upon cotton has been sufficiently explained in the articles CALICO PRINTING and DYEING.

GREEN DYE is produced by the mixture of a blue and yellow dye, the blue being first applied. See DYEING; as also BLUE and YELLOW DYES, and CALICO PRINTING.

GREEN PAINTS. (*Couleurs vertes*, Fr.; *Grüne pigmente*, Germ.) Green, which is so common a color in the vegetable kingdom, is very rare in the mineral. There is only one metal, copper, which affords in its combinations the various shades of green in general use. The other metals capable of producing this color are, chromium in its protoxyde, nickel in its hydrated oxyde, as well as its salts, the seleniate, arseniate, and sulphate; and titanium in its prussiate.

Green pigments are prepared also by the mixture of yellows and blues; as, for example, the green of Rinman and of Gellert, obtained by the mixture of cobalt blue, and flowers of zinc; that of Barth, made with yellow lake, Prussian blue, and clay; but these paints seldom appear in the market, because the greens are generally extemporaneous preparations of the artists.

Mountain green consists of the hydrate, oxyde, or carbonate of copper, either factitious, or as found in nature.

Bremen or *Brunswick green* is a mixture of carbonate of copper with chalk or lime, and sometimes a little magnesia or ammonia. It is improved by an admixture of white lead. It may be prepared by adding ammonia to a mixed solution of sulphate of copper and alum.

Frize green is prepared with sulphate of copper and sal ammoniac.

Mittis green is an arseniate of copper; made by mixing a solution of acetate or sulphate of copper with arsenite of potash. It is in fact Scheele's green.

Sap green is the inspissated juice of buckthorn berries. These are allowed to ferment for 8 days in a tub, then put in a press, adding a little alum to the juice, and concentrated by gentle evaporation. It is lastly put up in pigs' bladders, where it becomes dry and hard.

Schweinfurt green; see SCHWEINFURT.

Verona green is merely a variety of the mineral called green earth.

GREEN VITRIOL is sulphate of iron in green crystals.

GUAIAC (*Gaiac*, Fr.; *Guajaharz*, Germ.) is a resin which exudes from the trunk of the *Guaiacum officinale*, a tree which grows in the West India islands. It comes to us in large greenish-brown, semi-transparent lumps, having a conchoidal or splintery fracture, brittle, and easy to pulverize. It has an aromatic smell, a bitterish, acrid taste, melts with heat, and has a spec. grav. of from 1·20 to 1·22. It consists of 67·88 carbon; 7·05 hydrogen; and 25·07 oxygen; and contains two different resins, the one of which is soluble in all proportions in ammonia, and the other forms, with water of ammonia, a tarry consistenced mixture. It is soluble in alkaline leys, in alcohol, incompletely in ether, still less so in oil of turpentine, and not at all in fat oils. Its chief use is in medicine.

GUANO is a substance of a dark yellow color; of a strong ambrosial smell; which blackens in the fire, with the exhalation of an ammoniacal odor; soluble with effervescence in hot nitric acid. When this solution is evaporated to dryness, it assumes

a fine red color, evincing the presence of uric acid. Guano is found upon the coasts of Peru, in the islands of Chinche, near Pisco, and several other places more to the south. It forms a deposite 50 or 60 feet thick, and of considerable extent; and appears to be the accumulation of the excrements of innumerable flocks of birds, especially herons and flamands, which inhabit these islands. It is an excellent manure, and forms the object of a most extensive and profitable trade.

GUM (*Gomme,* Fr.; *Gummi, Pflanzenschleim,* Germ.) is the name of a proximate vegetable product, which forms with water a slimy solution, but is insoluble in alcohol, ether, and oils; it is converted by strong sulphuric acid into oxalic and mucic acids.

There are six varieties of gum: 1. gum arabic; 2. gum senegal; 3 gum of the cherry and other stone fruit trees: 4. gum tragacanth; 5. gum of Bassora; 6. the gum of seeds and roots. The first five spontaneously flow from the branches and trunks of their trees, and sometimes from the fruits, in the form of a mucilage which dries and hardens in the air. The sixth kind is extracted by boiling water.

Gum arabic and gum senegal consist almost wholly of the purest gum called *arabine* by the French chemists; our native fruit trees contain some *cerasine,* along with arabine; the gum of Bassora and gum tragacanth consist of arabine and bassorine.

Gum arabic flows from the *acacia arabica,* and the *acacia vera,* which grow upon the banks of the Nile and in Arabia. It occurs in commerce in the form of small pieces, rounded upon one side and hollow upon the other. It is transparent, without smell, brittle, easy to pulverize, sometimes colorless, sometimes with a yellow or brownish tint. It may be bleached by exposure to the air and the sun-beams, at the temperature of boiling water. Its specific gravity is 1·355. Moistened gum arabic reddens litmus paper, owing to the presence of a little supermalate of lime, which may be removed by boiling alcohol; it shows also traces of the chlorides of potassium and calcium, and the acetate of potash. 100 parts of good gum contain 70·40 of arabine, 17·60 of water, with a few per cents. of saline and earthy matters. Gum arabic is used in medicine, as also to give lustre to crapes and other silk stuffs.

Gum senegal is collected by the negroes during the month of November, from the *acacia senegal,* a tree 18 or 20 feet high. It comes to us in pieces about the size of a partridge egg, but sometimes larger, with a hollow centre. Its specific gravity is 1·436. It consists of 81·10 arabine; 16·10 water; and from 2 to 3 of saline matters. The chemical properties and uses of this gum are the same as those of gum arabic. It is much employed in calico-printing.

Cherry-tree gum consists of 52·10 arabine; 54·90 cerasine; 12 water; and 1 saline matter.

Gum tragacanth is gathered about the end of June, from the *astragalus tragacantha* of Crete and the surrounding islands. It has the appearance of twisted ribands; is white or reddish; nearly opaque, and a little ductile. It is difficult to pulverize, without heating the mortar. Its specific gravity is 1·384. When plunged in water, it dissolves in part, swells considerably, and forms a very thick mucilage. 100 parts of it consist of 53·30 arabine; 33·30 bassorine and starch; 11·0 water; and from 2 to 3 parts of saline matters. It is employed in calico printing, and by shoemakers.

Gum of Bassora; see BASSORINE.

Gum of seeds, as linseed, consists of 52·70 arabine; 28·9 of an insoluble matter; 10·3 water; and 7·11 saline matter. Neither bassorine nor cerasine seems to be present in seeds and roots. For *British Gum,* see STARCH.

GUM. RESINS. (*Gomme-résines,* Fr.; *Schleimharze,* Germ.) When incisions are made in the stems, branches, and roots of certain plants, a milky juice exudes, which gradually hardens in the air; and appears to be formed of resin and essential oil, held suspended in water charged with gum, and sometimes with other vegetable matters, such as caoutchouc, bassorine, starch, wax, and several saline matters. The said concrete juice is called a gum-resin; an improper name, as it gives a false idea of the nature of the substance. They are all solid; heavier than water; in general opaque and brittle; many have an acrid taste, and a strong smell; their color is very variable. They are partially soluble in water, and also in alcohol; and the solution in the former liquid seldom becomes transparent. Almost all the gum resins are medicinal substances, and little employed in the arts and manufactures. The following is a list of them: Asafœtida; gum ammoniac; bdellium; euphorbium; galbanum; gamboge; myrrh; olibanum or frankincense; opoponax; and scammony. Some of these are described in this work under their peculiar names.

GUNPOWDER. The following memoir upon this subject was published by me in the Journal of the Royal Institution for October, 1830. It contains the results of several careful analytical experiments, as also of observations made at the Royal Gunpowder works at Waltham Abbey, and at some similar establishments in the neighbourhood of London.

GUNPOWDER is a mechanical combination of nitre, sulphur, and charcoal; deriving

the intensity of its explosiveness from the purity of its constituents, the proportion in which they are mixed, and the intimacy of the admixture.

1. *On the nitre.*—Nitre may be readily purified, by solution in water and crystallization, from the muddy particles and foreign salts with which it is usually contaminated. In a saturated aqueous solution of nitre, boiling hot, the temperature is 240° F.; and the relation of the salt to its solvent is in weight as three to one, by my experiments: not five to one, as MM. Bottée and Riffault have stated. We must not, however, adopt the general language of chemists, and say that three parts of nitre are soluble in one of boiling water, since the liquid has a much higher heat and greater solvent power than this expression implies.

Water at 60° dissolves only one fourth of its weight of nitre; or, more exactly, this saturated solution contains 21 per cent. of salt. Its specific gravity is 1·1415; 100 parts in volume of the two constituents occupy now 97·91 parts. From these data we may perceive that little advantage could be gained in refining crude nitre, by making a boiling-hot saturated solution of it; since on cooling, the whole would concrete into a moist saline mass, consisting by weight of 2¾ parts of salt, mixed with 1 part of water, holding ¼ of salt in solution, and in bulk of 1⅓ of salt, with about 1 of liquid; for the specific gravity of nitre is 2·005, or very nearly the double of water. It is better, therefore, to use equal weights of saltpetre and water in making the boiling-hot solution. When the filtered liquid is allowed to cool slowly, somewhat less than three fourths of the nitre will separate in regular crystals; while the foreign salts that were present will remain with fully one fourth of nitre in the mother liquor. On redissolving these crystals with heat, in about two thirds of their weight of water, a solution will result, from which crystalline nitre, fit for every purpose, will concrete on cooling.

As the principal saline impurity of saltpetre is muriate of soda (a substance scarcely more soluble in hot than in cold water), a ready mode thence arises of separating that salt from the nitre in mother waters that contain them in nearly equal proportion. Place an iron ladle or basin, perforated with small holes, on the bottom of the boiler in which the solution is concentrating. The muriate. as it separates by the evaporation of the water, will fall down and fill the basin, and may be removed from time to time. When small needles of nitre begin to appear, the solution must be run off into the crystallizing cooler, in which moderately pure nitre will be obtained, to be refined by another similar operation.

At the Waltham Abbey gunpowder works the nitre is rendered so pure by successive solutions and crystallizations, that it causes no opalescence in a solution of nitrate of silver. Such crystals are dried, fused in an iron pot at a temperature of from 500° to 600° F., and cast into moulds. The cakes are preserved in casks.

About the period of 1794 and 1795, under the pressure of the first wars of their revolution, the French chemists employed by the government contrived an expeditious, economical, and sufficiently effective mode of purifying their nitre. It must be observed that this salt, as brought to the gunpowder-works in France, is in general a much cruder article than that imported into this country from India. It is extracted from the nitrous salts contained in the mortar-rubbish of old buildings, especially those of the lowest and filthiest descriptions. By their former methods, the French could not refine their nitre in less time than eight or ten days; and the salt was obtained in great lumps, very difficult to dry and divide; whereas the new process was so easy and so quick, that in less than twenty-four hours, at one period of pressure, the crude saltpetre was converted into a pure salt, brought to perfect dryness, and in such a state of extreme division as to supersede the operations of grinding and sifting, whence also considerable waste was avoided.

The following is a brief outline of this method, with certain improvements, as now practised in the establishment of the *Administration des poudres et saltpêtres,* in France.

The refining boiler is charged over night with 600 kilogrammes of water, and 1200 kilogrammes of saltpetre, as delivered by the salpêtriers. No more fire is applied than is adequate to effect the solution of this first charge of saltpetre. It may here be observed, that such an article contains several deliquescent salts, and is much more soluble than pure nitre. On the morrow morning the fire is increased, and the boiler is charged at different intervals with fresh doses of saltpetre, till the whole amounts to 3000 kilogrammes. During these additions, care is taken to stir the liquid very diligently, and to skim off the froth as it rises. When it has been for some time in ebullition, and when it may be presumed that the solution of the nitrous salts is effected, the muriate of soda is scooped out from the bottom of the boiler, and certain affusions or inspersions of cold water are made into the pot, to quicken the precipitation of that portion which the boiling motion may have kept afloat. When no more is found to fall, one kilogramme of Flanders glue, dissolved in a sufficient quantity of hot water, is poured into the boiler; the mixture is thoroughly worked together, the froth being skimmed off, with several successive inspersions of cold water, till 400 additional kilogrammes have been introduced, constituting altogether 1000 kilogrammes.

When the refining liquor affords no more froth, and is grown perfectly clear, all manipulation must cease. The fire is withdrawn, with the exception of a mere kindling, so as to maintain the temperature till the next morning at about 88° C. = 190·4 F.

This liquor is now transferred by hand-basins into the crystallizing reservoirs, taking care to disturb the solution as little as possible, and to leave untouched the impure matter at the bottom. The contents of the long crystallizing cisterns are stirred backwards and forwards with wooden paddles, in order to quicken the cooling, and the consequent precipitation of the nitre in minute crystals. These are raked, as soon as they fall, to the upper end of the doubly-inclined bottom of the crystallizer, and thence removed to the washing chests or boxes. By the incessant agitation of the liquor, no large crystals of nitre can possibly form. When the temperature has fallen to within 7° or 8° F., of the apartment, that is, after seven or eight hours, all the saltpetre that it can yield will have been obtained. By means of the double inward slope given to the crystallizer, the supernatant liquid is collected in the middle of the breadth, and may be easily laded out.

The saltpetre is shovelled out of the crystallizer into the washing chests, and heaped up in them so as to stand about six or seven inches above their upper edges, in order to allow for the subsidence which it must experience in the washing process. Each of these chests being thus filled, and their bottom holes being closed with plugs, the salt is besprinkled from the rose of a watering-can, with successive quantities of water saturated with saltpetre, and also with pure water, till the liquor, when allowed to run off, indicates by the hydrometer, a saturated solution. The water of each sprinkling ought to remain on the salt for two or three hours; and then it may be suffered to drain off through the plug-holes below, for about an hour.

All the liquor of drainage from the first watering, as well as a portion of the second, is set aside, as being considerably loaded with the foreign salts of the nitre, in order to be evaporated in the sequel with the mother waters. The last portions are preserved, because they contain almost nothing but nitre, and may therefore serve to wash another dose of that salt. It has been proved by experience, that the quantity of water employed in washing need never exceed thirty-six sprinklings in the whole, composed of three waterings, of which the first two consist of fifteen, and the last of six pots = 3 gallons E.; or in other words, of fifteen sprinklings of water saturated with saltpetre, and twenty-one of pure water.

The saltpetre, after remaining five or six days in the washing chests, is transported into the drying reservoirs, heated by the flue of the nearest boiler; here it is stirred up from time to time with wooden shovels, to prevent its adhering to the bottom, or running into lumps, as well as to quicken the drying process. In the course of about four hours, it gets completely dry, in which state it no longer sticks to the shovel, but falls down into a soft powder by pressure in the hand, and is perfectly white and pulverulent. It is now passed through a brass sieve, to separate any small lumps or foreign particles accidentally present, and is then packed up in bags or barrels. Even in the shortest winter days, the drying basin may be twice charged, so as to dry 700 or 800 kilogrammes. By this operation, the nett produce of 3000 kilogrammes (3 tons) thus refined, amounts to from 1750 to 1800 kilogrammes of very pure nitre, quite ready for the manufacture of gunpowder.

The mother waters are next concentrated; but into their management it is needless to enter in this memoir.

On reviewing the above process as practised at present, it is obvious that, to meet the revolutionary crisis, its conductors must have shortened it greatly, and have been content with a brief period of drainage.

2. *On the sulphur.*—The sulphur now imported into this country, from the volcanic districts of Sicily and Italy, for our manufactories of sulphuric acid, is much purer than the sulphur obtained by artificial heat from any varieties of pyrites, and may, therefore, by simple processes, be rendered a fit constituent of the best gunpowder. As it is not my purpose here to repeat what may be found in common chemical compilations, I shall say nothing of the sublimation of sulphur; a process, moreover, much too wasteful for the gunpowder-maker.

Sulphur may be most easily analyzed, even by the manufacturer himself; for I find it to be soluble in one tenth of its weight of boiling oil of turpentine, at 316° Fahrenheit, forming a solution which remains clear at 180°. As it cools to the atmospheric temperature, beautiful crystalline needles form, which may be washed sufficiently with cold alcohol, or even tepid water. The usual impurities of the sulphur, which are carbonate and sulphate of zinc, oxyde and sulphuret of iron, sulphuret of arsenic and silica, will remain unaffected by the volatile oil, and may be separately eliminated by the curious, though such separation is of little practical importance.

Two modes of refining sulphur for the gunpowder works have been employed; the first is by fusion, the second by distillation. Since the combustible solid becomes so

limpid as water, at the temperature of about 230° Fahrenheit, a ready mode offers of removing at once its denser and lighter impurities, by subsidence and skimming. But I may take the liberty of observing, that the French melting pot, as described in the elaborate work of MM. Bottée and Riffault, is singularly ill-contrived, for the fire is kindled right under it, and plays on its bottom. Now a pot for subsidence ought to be cold set; that is, should have its bottom part imbedded in clay or mortar for four or six inches up the side, and be exposed to the circulating flame of the fire only round its middle zone. This arrangement is adopted in many of our great chemical works, and is found to be very advantageous. With such a boiler, judiciously heated, I believe that crude sulphur might be made remarkably pure; whereas by directing the heat against the bottom of the vessel, the crudities are tossed up, and incorporated with the mass. See EVAPORATION.

The sulphur of commerce occurs in three prevailing colors; lemon yellow verging on green, dark yellow, and brown yellow. As these different shades result from the different degrees of heat to which it has been exposed in its original extraction on the great scale, we may thereby judge to what point it may still be heated anew in the refinery melting. Whatever be the actual shade of the crude article, the art of the refiner consists in regulating the heat, so that after the operation it may possess a brilliant yellow hue, inclining somewhat to green.

In seeking to accomplish this purpose, the sulphur should first be sorted according to its shades; and if a greenish variety is to be purified, since this kind has been but little heated in its extraction, the fusion may be urged pretty smartly, or the fire may be kept up till everything is melted but the uppermost layer.

Sulphur of a strong yellow tinge cannot bear so great a heat, and therefore the fire must be withdrawn whenever three fourths of the whole mass have been melted.

Brown-colored brimstone, having been already somewhat scorched, should be heated as little as possible, and the fire may be removed as soon as one half of the mass is fused.

Instead of melting, separately, sulphurs of different shades, we shall obtain a better result by first filling up the pot to half its capacity, with the greenish-colored article, putting over this layer one quarter volume of the deep yellow, and filling it to the brim with the brown-colored. The fire must be extinguished as soon as the yellow is fused. The pot must then be closely covered for some time; after which the lighter impurities will be found on the surface in a black froth, which is skimmed off, and the heavier ones sink to the bottom. The sulphur itself must be left in the pot for ten or twelve hours, after which it is laded out into the crystallizing boxes or casks.

Distillation affords a more complete and very economical means of purifying sulphur, which was first introduced into the French gunpowder establishments, when their importation of the best Italian and Sicilian sulphur was obstructed by the British navy. Here the sulphur need not come over slowly in a rare vapor, and be deposited in a pulverulent form called flowers; for the only object of the refiner is to bring over the whole of the pure sulphur into his condensing chamber, and to leave all its crudities in the body of the still. Hence a strong fire is applied to elevate a denser mass of vapors, of a yellowish color, which passing over into the condenser, are deposited in a liquid state on its bottom, whilst only a few lighter particles attach themselves to the upper and lateral surfaces. The refiner must therefore give to the heat in this operation very considerable intensity; and, at some height above the edge of the boiler, he should provide an inclined plane, which may let the first ebullition of the sulphur overflow into a safety recipient. The condensing chamber should be hot enough to maintain the distilled sulphur in a fluid state—an object most readily procured by leading the pipes of several distilling pots into it; while the continuity of the operations is secured, by charging each of the stills alternately, or in succession. The heat of the receiver must be never so high as to bring the sulphur to a sirupy consistence, whereby its color is darkened.

In the sublimation of sulphur, a pot containing about 4 cwts. can be worked off only once in twenty-four hours, from the requisite moderation of its temperature, and the precaution of an inclined plane, which restores to it the accidental ebullitions. But, by distillation, a pot containing fully ten cwts. may complete one process in nine hours at most, with a very considerable saving of fuel. In the former plan of procedure, an interval must elapse between the successive charges; but in the latter, the operation must be continuous to prevent the apparatus from getting cooled; in sublimation, moreover, where communication of atmospheric air to the condensing chamber is indispensable, explosive combustions of the sulphurous vapors frequently occur, with a copious production of sulphurous acid, and correspondent waste of the sulphur; disadvantages from which the distillatory process is in a great measure exempt.

I shall here describe briefly the form and dimensions of the distilling apparatus employed at Marseilles in purifying sulphur for the national gunpowder works, which

was found adequate to supply the wants of Napoleon's great empire. This apparatus consists of only two still-pots of cast iron, formed like the large end of an egg, each about three feet in diameter, two feet deep, and nearly half an inch thick at the bottom, but much thinner above, with a horizontal ledge four inches broad. A pot of good cast iron is capable of distilling 1000 tons of sulphur before it is rendered unserviceable, by the action of the brimstone on its substance, aided by a strong red heat. The pot is covered in with a sloping roof of masonry, the upper end of which abuts on the brickwork of the vaulted dome of condensation. A large door is formed in the masonry in front of the mouth of the pot, through which it is charged and cleared out; and between the roof-space over the pot, and the cavity of the vault, a large passage is opened. At the back of the pot a stone step is raised to prevent the sulphur boiling over into the condenser. The vault is about ten feet wide within, and fourteen feet from the bottom up to the middle of the dome, which is perforated, and carries a chimney about twelve feet high, and twelve feet diameter inside.

As the dome is exposed to the expansive force of a strong heat, and to a very considerable pressure of gases and vapors, it must possess great solidity, and be therefore bound with iron straps. Between the still and the contiguous wall of the condensing chamber, a space must be left for the circulation of air; a precaution found by experience indispensable; for the contact of the furnaces would produce on the wall of the chamber such a heat as to make it crack and form crevices for the liquid sulphur to escape. The sides of the chamber are constructed of solid masonry, forty inches thick, surmounted by a brick dome, covered with a layer of stones. The floor is paved with tiles, and the walls are lined with them up to the springing of the dome; a square hole being left in one side, furnished with a strong iron door, at which the liquid sulphur is drawn off at proper intervals. In the roof of the vault are two valve-holes covered with light plates of sheet-iron, which turn freely on hinges at one end, so as to give way readily to any sudden expansion from within, and thus prevent dangerous explosions.

As the chamber of condensation is an oblong square, terminating upwards in an oblong vault, it consists of a parallelopiped below, and semi-cylinder above, having the following dimensions:—

Length of the parallelopiped	$16\frac{1}{2}$ feet.
Width	$10\frac{3}{4}$
Height	$7\frac{1}{4}$
Radius of the cylinder	$5\frac{2}{5}$
Height or length of semi-cylinder . . .	$16\frac{1}{2}$

Whenever the workman has introduced into each pot its charge of ten or twelve hundred weight of crude sulphur, he closes the charging doors carefully with their iron plates and cross-bars, and lutes them tight with loam. He then kindles his fire, and makes the sulphur boil. One of his first duties (and the least neglect in its discharge may occasion serious accidents) is to inspect the roof-valves and to clean them, so that they may play freely and give way to any expulsive force from within. By means of a cord and chain, connected with a crank attached to the valves, he can, from time to time, ascertain their state, without mounting on the roof. It is found proper to work one of the pots a certain time before fire is applied to the other. The more steadily vapors of sulphur are seen to issue from the valves, the less atmospherical air can exist in the chamber, and therefore the less danger there is of combustion. But if the air be cold, with a sharp north wind, and if no vapors be escaping, the operator should stand on his guard, for in such circumstances a serious explosion may ensue.

As soon as both the boilers are in full work the air is expelled, the fumes cease, and every hazard is at an end. He should bend his whole attention to the cutting off all communication with the atmosphere, secuiing simply the mobility of the valves, and a steady vigor of distillation. The conclusion of the process is ascertained by introducing his sounding-rod into the pot, through a small orifice made for its passage in the wall. A new charge must then be given.

By the above process, well conducted, sulphurs are brought to the most perfect state of purity that the arts can require; while not above four parts in the hundred of the sulphur itself are consumed; the crude, incombustible residuum varying from five to eight parts, according to the nature of the raw material. But in the sublimation of sulphur, the frequent combustions inseparable from this operation carry the loss of weight in flowers to about twenty per cent. See SULPHUR, for a figure of the subliming apparatus.

The process by fusion, performed at some of the public works in this country, does not afford a return at all comparable with that of the above French process, though a much better article is operated upon in England. After two meltings of rough sulphur (as imported from Sicily or Italy), eighty-four per cent. is the maximum amount

obtained, the average being probably under eighty; while the product is certainly inferior in quality to that by distillation.

3. *On the charcoal.*—Tender and light woods, capable of affording a friable and porous charcoal, which burns rapidly away, leaving the smallest residuum of ashes, and containing therefore the largest proportion of carbon, ought to be preferred for charring in gunpowder works.

After many trials made long ago, black dogwood came to be preferred to every plant for this purpose; but modern experiments have proved that many other woods afford an equally suitable charcoal. The woods of black alder, poplar, lime-tree, horse-chestnut, and chestnut-tree, were carbonized in exactly similar circumstances, and a similar gunpowder was made with each, which was proved by the same proof-mortar. The following results were obtained :—

					Toises.	Feet.
Poplar—mean range	.	-	-	-	113	2
Black alder -	-	-	-	-	110	4
Lime -	-	-	-	-	110	3
Horse-chestnut	-	-	-	-	110	3
Chestnut-tree	-	-	-	-	109	

By subsequent experiments, confirmatory of the above, it has been further found that the willow presents the same advantages as the poplar, and that several shrubs, such as the hazel-nut, the spindle-treee, the dogberry, the elder-tree, the common sallow, and some others, may be as advantageously employed. But whichever wood be used, we should always cut it when full of sap, and never after it is dead; we should choose branches not more than five or six years old, and strip them carefully, because the old branches and the bark contain a larger proportion of earthy constituents. The branches ought not to exceed three quarters of an inch in thickness, and the larger ones should be divided lengthwise into four, so that their pith may be readily burned away.

Wood is commonly carbonized in this country into gunpowder-charcoal in cast-iron cylinders, with their axes laid horizontally, and built in brick-work, so that the flame of a furnace may circulate round them. One end of the cylinder is furnished with a door, for the introduction of the wood and the removal of the charcoal; the other end terminates in a pipe, connected with a worm-tub for condensing the pyroligneous acid, and giving vent to the carbureted hydrogen gases that are disengaged. Towards the end of the operation, the connexion of the cylinder with the pyroligneous acid cistern ought to be cut off, and a very free egress opened for the volatile matter, otherwise the charcoal is apt to get coated with a fuliginous varnish, and to be even penetrated with condensable matter, which materially injure its qualities.

In France, the wood is carbonized for the gunpowder works either in oblong vaulted ovens, or in pits, lined with brick-work or cylinders of strong sheet-iron. In either case, the heat is derived from the imperfect combustion of the wood itself to be charred. In general, the product in charcoal by the latter method is from 16 to 17 parts, by weight, from 100 of wood. The pit-process is supposed to afford a more productive return, and a better article; since the body of wood is much greater, and the fuliginous vapors are allowed a freer escape. The surface of a good charcoal should be smooth, but not glistening. See CHARCOAL.

The charcoal is considered by the scientific manufacturers to be the ingredient most influential, by its fluctuating qualities, upon the composition of gunpowder; and, therefore, it ought always to be prepared under the vigilant and skilful eye of the director of the powder establishment. If it has been kept for some time, or quenched at first with water, it is unsuitable for the present purpose. Charcoal extinguished in a close vessel by exclusion of air, and afterwards exposed to the atmosphere, absorbs only from three to four per cent. of moisture, while red-hot charcoal quenched with water may lose by drying twenty-nine per cent. When the latter sort of charcoal is used for gunpowder, a deduction of weight must be made for the water present. But charcoal which has remained long impregnated with moisture, constitutes a most detrimental ingredient of gunpowder.

4. *On mixing the Constituents and forming the Powder.*

The three ingredients thus prepared are ready for manufacturing into gunpowder. They are, 1. Separately ground to a fine powder, which is passed through sorted silk sieves or bolting machines. 2. They are mixed together in the proper proportions, which we shall afterwards discuss. 3. The composition is then sent to the gunpowder

mill, which consists of two edge-stones of a calcareous kind, turning by means of a horizontal shaft, on a bed-stone of the same nature; incapable of affording sparks by collision with steel, as sand-stones would do. On this bed-stone the composition is spread, and moistened with as small a quantity of water as will, in conjunction with the weight of the revolving stones, bring it into a proper body of cake, but by no means into a pasty state. The line of contact of the rolling edge-stone is constantly preceded by a hard copper scraper, which goes round with the wheel, regularly collecting the caking mass, and bringing it into the track of the stone. From 50 to 60 pounds of cake are usually worked at one operation, under each millstone. When the mass has been thoroughly kneaded and incorporated, it is sent to the corning-house, where a separate mill is employed to form the cake into grains or corns. Here it is first pressed into a hard firm mass, then broken into small lumps; after which the corning process is performed, by placing these lumps in sieves, on each of which is laid a disc or flat cake of lignum vitæ. The sieves are made of parchment skins, or of copper, perforated with a multitude of round holes. Several such sieves are fixed in a frame, which, by proper machinery, has such a motion given to it as to make the lignum vitæ running in each sieve move about with considerable velocity, so as to break down the lumps of the cake, and force its substance through the holes, in grains of certain sizes. These granular particles are afterwards separated from the finer dust by proper sieves and reels.

The corned powder must now be hardened, and its rougher angles removed, by causing it to revolve in a close reel or cask turning rapidly round its axis. This vessel resembles somewhat a barrel-churn, and is frequently furnished inside with square bars parallel to its axis, to aid the polish by attrition.

The gunpowder is finally dried, which is now done generally with a steam heat, or in some places by transmitting a current of air, previously heated in another chamber, over canvass shelves, covered with the damp grains.

5. On the proportion of the Constituents.

A very extensive suite of experiments, to determine the proportions of the constituents for producing the best gunpowder, was made at the Essonne works, by a commission of French chemists and artillerists, in 1794.

Powders in the five following proportions were prepared :—

	Nitre.	Charcoal.	Sulphur.	
1	76	14	10	Gunpowder of Bâle.
2	76	12	12	Gunpowder works of Grenelle.
3	76	15	9	M. Guyton de Morveau.
4	77·32	13·44	9·24	Idem.
5	77·5	15	7·5	M. Riffault.

The result of more than two hundred discharges with the proof-mortar showed that the first and third gunpowders were the strongest; and the commissioners in consequence recommended the adoption of the third proportions. But a few years thereafter it was thought proper to substitute the first set of proportions, which had been found equal in force to the other, as they would have a better keeping quality, from containing a little more sulphur and less charcoal. More recently still, so strongly impressed have the French government been with the high value of durability in gunpowders, that they have returned to their ancient dosage of 75 nitre, 12½ charcoal, and 12½ sulphur. In this mixture, the proportion of the substance powerfully absorbent of moisture, viz., the charcoal, is still further reduced, and replaced by the sulphur, or the conservative ingredient.

If we inquire how the maximum gaseous volume is to be produced from the chemical reaction of the elements of nitre on charcoal and sulphur, we shall find it to be by the generation of carbonic oxyde and sulphurous acid, with the disengagement of nitrogen. This will lead us to the following proportions of these constituents.

			Hydrogen = 1.	Per cent
1 prime equivalent of nitre -	-	-	102	75·00
1 sulphur	-	-	16	11·77
3 charcoal	-	-	18	13·23
			136	100·00

The nitre contains.five primes of oxygen, of which three, combining with the three of charcoal, will furnish three of carbonic oxyde gas, while the remaining two will convert the one prime of sulphur into sulphurous acid gas. The single prime of nitrogen is, therefore, in this view, disengaged alone.

The gaseous volume, on this supposition, evolved from 136 grains of gunpowder, equivalent in bulk to 75¼ grains of water, or to three tenths of a cubic inch, will be, at the atmospheric temperature, as follows :—

	Grains.	Cubic Inches.
Carbonic oxyde - - - - -	42 =	141·6
Sulphurous acid - - - - -	32 =	47·2
Nitrogen - - - - - -	14 =	47·4
		236·2

being an expansion of one volume into 787·3. . But as the temperature of the gases at the instant of their combustive formation must be incandescent, this volume may be safely estimated at three times the above amount, or considerably upwards of two thousand times the bulk of the explosive solid.

But this theoretical account of the gases developed does not well accord with the experimental products usually assigned, though these are probably not altogether exact. Much carbonic acid is said to be disengaged, a large quantity of nitrogen, a little oxyde of carbon, *steam of water*, with *carbureted and sulphureted hydrogen*. From experiments to be presently detailed, I am convinced that the amount of these latter products printed in italics must be very inconsiderable indeed, and unworthy of ranking in the calculation; for, in fact, fresh gunpowder does not contain above one per cent. of water, and can therefore yield little hydrogenated matter. Nor is the hydrogen in the carbon of any consequence.

It is obvious that the more sulphur is present, the more of the dense sulphurous acid will be generated, and the less forcibly explosive will be the gunpowder. This is sufficiently confirmed by the trials at Essonne, where the gunpowder that contained 12 of sulphur and 12 of charcoal in 100 parts, did not throw the proof-shell so far as that which contained only 9 of sulphur and 15 of charcoal. The conservative property is, however, so capital, especially for the supply of our remote colonies and for humid climates, that it justifies a slight sacrifice of strength, which at any rate may be compensated by a small addition of charge.

Table of Composition of different Gunpowders.

	Nitre.	Charcoal.	Sulphur.
Royal Mills at Waltham Abbey - - -	75	15	10
France, national establishment - -	75	12·5	12·5
French, for sportsmen - - - -	78	12	10
French, for mining - - - - -	65	15	20
United States of America - - - -	75	12·5	12·5
Prussia - - - - - - -	75	13·5	11·5
Russia - - - - - - -	73·78	13·59	12·63
Austria (*musquet*) - - - - -	72	17	16
Spain - - - - - - -	76·47	10·78	12·75
Sweden - - - - - - -	76	15	9
Switzerland (a round powder) - - -	76	14	10
Chinese - - - - - - -	75	14·4	9·9
Theoretical proportions (as above) - -	75	13·23	11.77

6. On the Chemical Examination of Gunpowders.

I have treated five different samples: 1. The government powder made at Waltham Abbey; 2. Glass gunpowder made by John Hall, Dartford; 3. The treble strong gunpowder of Charles Lawrence and Son; 4. The Dartford gunpowder of Pigou and Wilks; 5. Superfine treble strong sporting gunpowder of Curtis and Harvey. The first is coarse-grained, the others are all of considerable fineness. The specific gravity of each was taken in oil of turpentine: that of the first and last three was exactly the same, being 1·80; that of the second was 1·793, all being reduced to water as unity.

The above density for specimen first, may be calculated thus :—

75 parts of nitre, specific gravity = 2·000
15 parts of charcoal, specific gr. = 1·154
10 parts of sulphur, specific gr. = 2·000

The volume of these constituents is 55·5 (the volume of their weight of water being 100); by which if their weight 100 be divided, the quotient is 1·80.

The specific gravity of the first and second of the above powders, including the interstices of their grains, after being well shaken down in a vial, is 1·02. This is a curious result, as the size of the grains is extremely different. That of Pigou and Wilks, similarly tried, is only 0·99; that of the Battle powder is 1·03; and that of Curtis and Harvey is nearly 1·05. Gunpowders thus appear to have nearly the same weight as water, under an equal bulk; so that an imperial gallon will hold from 10 pounds to 10 pounds and a half, as above shown.

The quantities of water which 100 grains of each part with on a steam bath, and absorb when placed for 24 hours under a moistened receiver standing in water, are as follows :—

100 grains of Waltham Abbey, lose 1·1 by steam heat, gain 0·8 over water.
        of Hall   -   - 0·5   -   -   - 2·2
           Lawrence -   - 1·0   -   -   - 1·1
           Pigou and Wilks -   - 0·6   -   -   - 2·2
           Curtis and Harvey -   0·9   -   -   - 1·7

Thus we perceive that the large grained government powder resists the hygrometric influence better than the others; among which, however, Lawrence's ranks nearly as high. These two are therefore relatively the best keeping gunpowders of the series.

The process most commonly practised in the analysis of gunpowder, seems to be tolerably exact. The nitre is first separated by hot distilled water, evaporated and weighed. A minute loss of salt may be counted on, from its known volatility with boiling water. I have evaporated always on a steam bath. It is probable that a small portion of the lighter and looser constituent of gunpowder, the carbon, flies off in the operations of corning and dusting. Hence, analysis may show a small deficit of charcoal below the synthetic proportions originally mixed. The residuum of charcoal and sulphur left on the double filter-paper, being well dried by the heat of ordinary steam, was estimated, as usual, by the difference of weight of the inner and outer papers. This residuum was cleared off into a platina capsule with a tooth-brush, and digested in a dilute solution of potash at a boiling temperature. Three parts of potash are fully sufficient to dissolve out one of sulphur. When the above solution is thrown on a filter, and washed first with a very dilute solution of potash boiling hot, then with boiling water, and afterwards dried, the carbon will remain; the weight of which deducted from that of the mixed powder, will show the amount of sulphur.

I have tried many other modes of estimating the sulphur in gunpowder more directly, but with little satisfaction in the results. When a platina capsule, containing gunpowder spread on its bottom, is floated in oil, heated to 400° Fahrenheit, a brisk exhalation of sulphur fumes rises, but, at the end of several hours, the loss does not amount to more than one half of the sulphur present.

The mixed residuum of charcoal and sulphur digested in hot oil of turpentine gives up the sulphur readily; but to separate again the last portions of the oil from the charcoal or sulphur, requires the aid of alcohol.

When gunpowder is digested with chlorate of potash and dilute muriatic acid, at a moderate heat in a retort, the sulphur is acidified; but this process is disagreeable and slow, and consumes much chlorate. The resulting sulphuric acid being tested by nitrate of baryta, indicates of course the quantity of sulphur in the gunpowder. A curious fact occurred to me in this experiment. After the sulphur and charcoal of the gunpowder had been quite acidified, I poured some solution of the baryta salt into the mixture, but no cloud of sulphate ensued. On evaporating to dryness, however, and redissolving, the nitrate of baryta became effective, and enabled me to estimate the sulphuric acid generated; which was of course 10 for every 4 of the sulphur.

The acidification of the sulphur by nitric or nitro-muriatic acid is likewise a slow and unpleasant operation.

By digesting gunpowder with potash water, so as to convert its sulphur into a sulphuret, mixing this with nitre in great excess, drying and igniting, I had hoped to convert the sulphur readily into sulphuric acid. But on treating the fused mass with dilute nitric acid, more or less sulphurous acid was exhaled. This occurred even though chlorate of potash had been mixed with the nitre to aid the oxygenation.

The following are the results of my analyses, conducted by the first described method :

100 grains afford, of	Nitre.	Charcoal.	Sulphur.	Water.
Waltham Abbey - -	74·5	14·4	10·0	1·1
Hall, Dartford - - -	76·2	14·0	9·0	0·5 loss 0·3
Pigou and Wilks - -	77·4	13·5	8·5	0·6
Curtis and Harvey -	76·7	12·5	9·0	1·1 loss 0·7
Battle gunpowder -	77·0	13·5	8·0	0·8 loss 0·7

It is probable, for reasons already assigned, that the proportions mixed by the manufacturers may differ slightly from the above.

The English sporting gunpowders have long been an object of desire and emulation in France. Their great superiority for fowling pieces over the product of the French national manufactories, is indisputable. Unwilling to ascribe this superiority to any genuine cause, M. Vergnaud, captain of French artillery, in a little work on fulminating powders lately published, asserts positively, that the English manufacturers of ' poudre de chasse' are guilty of the ' charlatanisme' of mixing fulminating mercury with it. To determine what truth was in this allegation, with regard at least to the above five celebrated gunpowders, I made the following experiments.

One grain of fulminating mercury, in crystalline particles, was mixed in water with 200 grains of the Waltham Abbey gunpowder, and the mixture was digested over a lamp with a very little muriatic acid. The filtered liquid gave manifest indications of the corrosive sublimate, into which fulminating mercury is instantly convertible by muriatic acid; for copper was quicksilvered by it; potash caused a white cloud in it that became yellow, and sulphureted hydrogen gas separated a dirty yellow white precipitate of bisulphuret of mercury. When the Waltham Abbey powder was treated alone with dilute muriatic acid, no effect whatever was produced upon the filtered liquid by the sulphureted hydrogen gas.

200 grains of each of the above sporting gunpowders were treated precisely in the same way, but no trace of mercury was obtained by the severest tests. Since by this process there is no doubt but one 10,000th part of fulminating mercury could be detected, we may conclude that Captain Vergnaud's charge is groundless. The superiority of our sporting gunpowders is due to the same cause as the superiority of our cotton fabrics—the care of our manufacturers in selecting the best materials, and their skill in combining them.

I shall subjoin here some miscellaneous observations upon gunpowder.

In Bengal, mixing is performed by shutting up the ingredients in barrels, which are turned either by hand or machinery; each containing 50 lbs. weight, or more, of small brass balls. They have ledges on the inside, which occasion the balls and composition to tumble about and mingle together, so that the intermixture of the ingredients, after the process has been gone through, cannot fail to be complete. The operation is continued two or three hours; and I think it would be an improvement in Her Majesty's system of manufacture if this method of mixing were adopted.

In England two or three pints of water are used for a 42 lb. charge : but the quantity is variable; both the temperature and the humidity of the atmosphere influence it.

Bramah's hydrostatic press, or a very strong wooden press working with a powerful screw, lever, and windlass, constitutes the description of mechanism by which density is imparted to gunpowder. The incorporated or mill-cake powder is laid on the bed or follower of the press, and separated, at equal distances, by sheets of copper, so that when the operation is over, it comes out in large thin solid cakes, or strata, distinguished by the term press-cake. The mill-cake powder at Waltham Abbey, is submitted to a mean theoretic pressure of 70 to 75 tons per superficial foot.

Gunpowder should be thoroughly dried, but not by too high a degree of heat; that of 140° or 150° of Fahrenheit's thermometer is sufficient. It appears to be of no consequence whether it be dried by solar heat, by radiation from red-hot iron, as in the gloom stove, or by a temperature raised by means of steam. Her Majesty's gunpowder is dried by the last two methods. The grain should not be suddenly exposed to the highest degree of heat, but gradually.

The method of trial best adapted to show the real inherent strength and goodness of gunpowder, appears to be an eight or ten inch iron or brass mortar, with a truly spherical solid shot, having not more than one tenth of an inch windage, and fired with a low charge. The eight-inch mortar, fired with two ounces of powder, is one of the established methods of proof at Her Majesty's works. Gunpowders that range equally in this mode of trial, may be depended on as being equally strong.

Another proof is by four drachms of powder laid in a small neat heap, on a clean, polished

copper plate; which heap is fired at the apex, by a red hot iron. The explosion should be sharp and quick; not tardy, nor lingering; it should produce a sudden concussion in the air; and the force and power of that concussion ought to be judged of by comparison with that produced by powder of known good quality. No sparks should fly off, nor should beads, or globules of alkaline residuum, be left on the copper. If the copper be left clean, i. e. without gross foulness, and no lights, i. e. sparks, be seen, the ingredients may be considered to have been carefully prepared, and the powder to have been well manipulated, particularly if pressed and glazed; but if the contrary be the result, there has been a want of skill or of carefulness manifested in the manufacture.

"Gunpowder," says Captain Bishop, "explodes exactly at the 600° of heat by Fahrenheit's thermometer; when gunpowder is exposed to 500° it alters its nature altogether; not only the whole of the moisture is driven off, but the saltpetre and sulphur are actually reduced to fusion, both of which liquefy under the above degree. The powder, on cooling, is found to have changed its color from a gray to a deep black; the grain has become extremely indurated, and by exposure even to very moist air, it then suffers no alteration by imbibing moisture."

The mill for grinding the gunpowder cake may be understood from the following

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representation (*fig.* 531); *p*, is the water wheel, which may drive several pairs of stones; *q, q*, two vertical bevel wheels, fixed upon the axis of the great wheel; *r*, *, two horizontal bevel wheels working in *q, q*, and turning the shafts *s*, *s*; *t, t*, two horizontal spur wheels fixed to the upper part of the vertical shafts, and driving the large wheels *u, u*. To the shafts of these latter wheels are fixed the runners *v, v*, which traverse upon the bed stone *w, w*; *x, x*, are the curbs surrounding the bed stone to prevent the powder from falling off; *o* is the scraper. Mill A represents a view, and mill B a section of the bed stone and curb.

GYPSUM, *Sulphate of lime, Alabaster, or Paris Plaster.* This substance is found in three geological positions in the crust of the earth; among transition rocks; in the red marl formation; and above the chalk, in the tertiary beds.

1. The alpine gypsums are ranged by M. Brochant among the transition class, and are characterized by the presence of anthracite or stone coal; some of them are white and pure, others gray or yellowish, and mixed with mica, talc, steatite, black oxyde of iron, pyrites, compact carbonate of lime, sulphur, and common salt. Examples of such localities are found in the gypsum of *Val-Canaria* at the foot of Saint Gothard, that of Brigg in the upper Valais; of the Grilla in the valley of Chamouni, and of Saint Gervais-les-Bains, near Sallenches in Savoy.

2. The secondary gypsum, or that of the salt mine districts, belongs to the *red ground,* immediately beneath the lias in the order of stratification, and therefore a rock relatively ancient. Near Northwick, the red marl beds above the great deposite of rock salt, are irregularly intersected with gypsum, in numerous laminæ or plates. At Newbiggin in Cumberland, the gypsum lies in red argillaceous marl, between two strata of sandstone; and a mile south of Whitehaven, the subterraneous workings for the alabaster extend 30 yards in a direct line; with two or three lateral branches extending about 10 yards, at whose extremities are large spaces where the gypsum is blasted with gunpowder. It is generally compact, forming a regular and conformable bed, with crystals of selenite (crystallized gypsum) in drusy cavities. Gypsum occurs in the red marl in the isle of Axholme, and various other places in Nottinghamshire. In Derbyshire some considerable deposites have been found in the same red sandstone, several of which are mined, as at Chellaston hill, which would exhibit a naked and water-worn rock of gypsum,

were it not for a covering of alluvial clay. It appears in general to present itself chiefly in particular patches, occasioning a sudden rise, or an insulated hill, by the additional thickness which it gives to the stratum of the *red ground* in these places. The principal demand for the pure white gypsum, or that faintly streaked with red, is by the potters in Staffordshire, who form their moulds with the calcined powder which it affords; only particularly fine blocks are selected for making alabaster ornaments on the turning lathe. In one of the salt pits near Droitwich, the strata sunk through, were vegetable mould, 3 feet; red marl, 35 feet; gypsum, 40 feet; a river of brine, 22 inches; gypsum, 75 feet; a rock of salt, bored into only 5 feet, but probably extending much deeper. On the Welsh side of the Bristol channel, gypsum occurs in the red marl cliffs of *Glamorganshire*, from Pennarth to Lavernock. No organic remains or metallic minerals have hitherto been found in the gypsum of this formation.

3. The most interesting gypsums in a general point of view, are certainly the tertiary, or those of the plains, or hills of comparatively modern formation. They are characterized by the presence of fossil bones of extinct animals, both *mammifera* and birds, by shells, and a large proportion of carbonate of lime, which gives them the property of effervescing with acids, and the title of limestone gypsums. Such are the gypsums of the environs of Paris, as at the heights of Montmartre, which contain crystallized sulphate of lime in many forms, but most commonly the lenticular and lance-shaped.

Sulphate of lime occurs either as a dense compound without water, and is called *anhydrite* from that circumstance; or with combined water, which is its most ordinary state. Of the latter there are 6 sub-species; sparry gypsum or selenite in a variety of crystalline forms; the foliated granular; the compact; the fibrous; the scaly foliated; the earthy.

The prevailing color is white, with various shades of gray, blue, red, and yellow. More or less translucent. Soft, sectile, yielding to the nail. Specific gravity 2·2. Water dissolves about one five-hundredth part of its weight of gypsum, and acquires the quality of hardness, with the characteristic selenitic taste. When exposed on red hot coals, it decrepitates, becomes white, and splits into a great many brittle plates. At the heat of a baker's oven, or about 400° Fahr., the combined water of gypsum escapes with a species of ebullition. At a higher temperature the particles get indurated. When rightly calcined and pulverized, gypsum is mixed with water to the consistence of cream, and poured into moulds by the manufacturers of stucco ornaments and statues. A species of rapid crystallization ensues, and the thin paste soon acquires a solid consistence, which is increased by drying the figure in proper stoves. During the consolidation of the plaster, its volume expands into the finest lines of the mould, so as to give a sharp and faithful impression.

The plaster stone of the Paris basin contains about 12 *per cent.* of carbonate of lime. This body, ground and mixed with water, forms an adhesive mortar much used in building, as it fixes very speedily. Works executed with pure gypsum never become so hard as those made with the calcareous kind; and hence it might be proper to add a certain portion of white slaked lime to our calcined gypsum, in order to give the stucco this valuable property. Colored stuccos of great solidity are made by adding to a clear solution of glue, any desired coloring tincture, and mixing-in the proper quantity of the calcined calcareous gypsum.

The compact, fine-grained, gypseous alabaster is often cut into various ornamental figures, such as vases, statuary groups, &c., which take a high polish and look beautiful, but from their softness are easily injured, and require to be kept enclosed within a glass shade.

In America and France, the virtues of gypsum in fertilizing land have been highly extolled, but they have not been realized in the trials made in this kingdom.

Pure gypsum consists of lime 28; sulphuric acid 40; water 18; which are the respective weights of its prime equivalent parts.

M. Gay Lussac, in a short notice, in the *Annales de Chimie* for April, 1829, on the setting of gypsum, says that the purest plasters are those which harden least, and that the addition of lime is of no use toward promoting their solidity, nor can the heat proper for boiling gypsum ever expel the carbonic acid gas from the calcareous carbonate present in the gypsum of Montmartre. He conceives that a *hard* plaster-stone having lost its water, will resume more solidity in returning to its first state, than a plaster-stone naturally tender or soft; and that it is the primitive molecular arrangement which is regenerated. See ALABASTER.

H.

HADE signifies, among English miners, the inclination, or deviation from the vertical of any mineral vein.

HAIR (*Cheveu, Crin,* Fr.; *Haar,* Germ.) is of all animal products, the one least liable to spontaneous change. It can be dissolved in water only at a temperature somewhat above 230° F., in a Papin's digester, but it appears to be partially decomposed by this heat, since some sulphureted hydrogen is disengaged. By dry distillation, hair gives off several sulphureted gases, while the residuum contains sulphate of lime, common salt, much silica, with some oxyde of iron and manganese. It is a remarkable fact that fair hair affords magnesia, instead of these latter two oxydes. Horse-hair yields about 12 per cent. of phosphate of lime.

Hairs are tubular, their cavities being filled with a fat oil, having the same color with themselves. Hair plunged in chlorine gas, is immediately decomposed and converted into a viscid mass; but when immersed in weak aqueous chlorine, it undergoes no change, except a little bleaching. The application of nitrate of mercury to hairy skins in the process of *secrétage,* is explained under PELTRY.

For the dyeing of horse-hair, see the next article.

Living hairs are rendered black by applying to them, for a short time, a paste made by mixing litharge, slaked lime, and bicarbonate of potash, in various proportions, according to the shade of color desired.

We have no recent analysis of hair. Vauquelin found nine different substances in black hair; in red hair, a red oil instead of a greenish-black one.

The salts of mercury, lead, bismuth, as well as their oxydes, blacken hair, or make it of a dark violet, by the formation, most probably, of metallic sulphurets.

Hair as an object of manufactures is of two kinds, the *curly* and the *straight.* The former, which is short, is spun into a cord, and boiled in this state, to give it the tortuous springy form. The long straight hair is woven into cloth for sieves, and also for ornamental purposes, as in the damask-hair cloth of chair bottoms. For this purpose the hair may be dyed in the following way.

Forty pounds of tail hair about 26 inches long are steeped in lime water during twelve hours. Then a bath is made with a decoction of 20 pounds of logwood, kept boiling for three hours, after which time the fire is withdrawn from the boiler, and ten ounces of copperas are introduced, stirred about, and the hair is immersed, having been washed from the lime in river water. The hair should remain in this cooling bath for 24 hours, when the operation will be finished. For other colors, see the respective dyes.

The looms for weaving hair differ from the common ones, only in the templet and the shuttle. Two templets of iron must be used to keep the stuff equably, but lightly stretched. These templets, of which one is represented in *fig.* 532, are constructed in the shape of flat pincers; the jaws c c being furnished with teeth inside. A screw D,

532
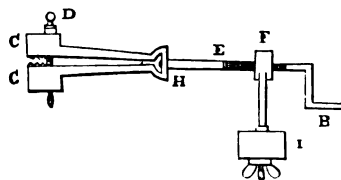
binds the jaws together, and hinders the selvage from going inwards. Upon the side cross beam of the loom, seen in section at I, a bolt is fixed which carries a nut F at its end, into which a screwed iron rod E enters, on one of whose ends is the handle B. The other extremity of the screw E is adapted by a washer and pin to the back of the pincers at the point H, so that by turning the handle to the right or the left, we draw onwards or push backwards the pincers and the stuff at pleasure. The warp of the web is made of black linen yarn. The weft is of hair, and it is thrown with a long hooked shuttle; or a long rod, having a catch hook at its end. The length of this shuttle is about 3 feet; its breadth half an inch, and its thickness one sixth. It is made of box-wood. The reed is of polished steel; the thread warps are conducted through it in the usual way. The workman passes this shuttle between the hairs of the warp with one hand, when the shed or shuttle way is opened by the treddles; a child placed on one side of the loom presents a hair to the weaver near the selvage, who catches it with the hook of his shuttle, and by drawing it out passes it through the warp. The hairs are placed in a bundle on the side where the child stands, in a chest filled with water to keep them moist, for otherwise they would not have the suppleness requisite to form a web. Each time that a hair is thrown across, the batten is driven home twice. The warp is dressed with paste in the usual way. The hair cloth, after it is woven, is hot calendered to give it lustre.

HAIR PENCILS OR BRUSHES for painting. Two sorts are made; those with coarse
ir, as that of the swine, the wild boar, the dog, &c., which are attached usually to short
oden rods as handles; these are commonly called *brushes;* and hair pencils, properly
called, which are composed of very fine hairs, as of the minever, the marten, the
dger, the polecat, &c. These are mounted in a quill when they are small or of mode-
te size, but when larger than a quill, they are mounted in white-iron tubes.

The most essential quality of a good pencil is to form a fine point, so that all the hairs
thout exception may be united when they are moistened by laying them upon the
ague, or drawing them through the lips. When hairs present the form of an elongated
ne in a pencil, their point only can be used. The whole difficulty consists after the
irs are cleansed, in arranging them together so that all their points may lie in the same
rizontal plane. We must wash the tails of the animals whose hairs are to be used,
scouring them in a solution of alum till they be quite free from grease, and then steep-
g them for 24 hours in luke-warm water. We next squeeze out the water by pressing
em strongly from the root to the tip, in order to lay the hairs as smooth as possible.
ey are to be dried with pressure in linen cloths, combed in the longitudinal direction,
th a very fine-toothed comb, finally wrapped up in fine linen, and dried. When per-
tly dry, the hairs are seized with pincers, cut across close to the skin, and arranged in
parate heaps, according to their respective lengths.

Each of these little heaps is placed separately, one after the other, in small tin pans
ith flat bottoms, with the tips of the hair upwards. On striking the bottom of the pan
ghtly upon a table, the hairs get arranged parallel to each other, and their delicate
ints rise more or less according to their lengths. The longer ones are to be picked out
d made into so many separate parcels, whereby each parcel may be composed of equally
ng hairs. The perfection of the pencil depends upon this equality; the tapering point
ing produced simply by the attenuation of the tips.

A pinch of one of these parcels is then taken, of a thickness corresponding to the in-
nded size of the pencil; it is set in a little tin pan, with its tips undermost, and is shaken
striking the pan on the table as before. The root end of the hairs being tied by the
herman's or seaman's knot, with a fine thread, it is taken out of the pan, and then
oped with stronger thread or twine; the knots being drawn very tight by means of two
tle sticks. The distance from the tips at which these ligatures are placed, is of course
lative to the nature of the hair, and the desired length of the pencil. The base of the
ncil must be trimmed flat with a pair of scissors.

Nothing now remains to be done but to mount the pencils in quill or tin-plate tubes as
ove described. The quills are those of swans, geese, ducks, lapwings, pigeons, or larks,
cording to the size of the pencil. They are steeped during 24 hours in water, to swell
d soften them, and to prevent the chance of their splitting when the hair brush is pressed
to them. The brush of hair is introduced by its tips into the large end of the cut quill,
ving previously drawn them to a point with the lips, when it is pushed forwards with
wire of the same diameter, till it comes out at the other and narrower end of the quill.
The smaller the pencils, the finer ought the hairs to be. In this respect, the manufacture
quires much delicacy of tact and experience. It is said that there are only four first-rate
nds among all the dexterous pencil-makers of Paris, and that these are principally women.

HALOGENE is a term employed by Berzelius to designate those substances which
rm compounds of a saline nature, by their union with metals; such are *Bromine,*
Uorine, Cyanogene, Fluorine, Iodine. *Haloid* is his name of the salt thereby formed.

HANDSPIKE is a strong wooden bar, used as a lever to move the windlass and cap-
an in heaving up the anchor, or raising any heavy weights on board a ship. The
ndle is smooth, round, and somewhat taper; the other end is squared to fit the holes in
e head of the capstan or barrel of the windlass.

HARDNESS (*Dureté,* Fr.; *Härte, Festigkeit,* Germ.) is that modification of cohesive
traction which enables bodies to resist any effort made to abrade their surfaces. Its rel-
ive intensity is measured by the power they possess of cutting or scratching other sub-
ances. The following table exhibits pretty nearly the successive hardnesses of the
veral bodies in the list:—

Substances.	Hardness.	Specific Gravity.
Diamond from Ormus - - - - -	20	3·7
Pink diamond - - - - -	19	3·4
Bluish diamond - - - - -	19	3·3
Yellowish diamond - - - - -	19	3·3
Cubic diamond - - - - - -	18	3·2
Ruby - - - - - -	17	4·2
Pale ruby from Brazil - - - -	16	3·5
Deep blue sapphire - - - -	16	3·8
Ditto, paler - - - - -	17	3·8
Topaz - - - - - -	15	4·2
Whitish topaz - - - - -	14	3·5
Ruby spinell - - - - -	13	3·4
Bohemian topaz - - - - -	11	2·8
Emerald - - - - -	12	2·8
Garnet - - - - - -	12	4·4
Agate - - - - -	12	2·6
Onyx - - - - -	12	2·6
Sardonyx - - - - -	12	2·6
Occidental amethyst - - - -	11	2·7
Crystal - - - - -	11	2·6
Cornelian - - - - -	11	2·7
Green jasper - - - - -	11	2·7
Reddish yellow do. - - - -	9	2·6
Schoerl - - - - -	10	3·6
Tourmaline - - - - -	10	3·0
Quartz - - - - -	10	2·7
Opal - - - - -	10	2·6
Chrysolite - - - - -	10	3·7
Zeolite - - - - -	8	2·1
Fluor - - - - -	7	3·5
Calcareous spar - - - -	6	2·7
Gypsum - - - - -	5	2·3
Chalk - - - - -	3	2·7

HARTSHORN, SPIRIT OF, is the old name for water of ammonia.

HATCHING OF CHICKENS. See INCUBATION, ARTIFICIAL.

HAT MANUFACTURE. (*L'art de Chapelier*, Fr.; *Hutmacherkunst*, Germ.) Hat is the name of a piece of dress worn upon the head by both sexes, but principally by the men, and seems to have been first introduced as a distinction among the ecclesiastics in the 12th century, though it was not till the year 1400 that it was generally adopted by respectable laymen.

As the art of making common hats does not involve the description of any curious machinery, or any interesting processes, we shall not enter into very minute details upon the subject. It will be sufficient to convey to the reader a general idea of the methods employed in this manufacture.

The materials used in making stuff hats are the furs of hares and rabbits freed from the long hair, together with wool and beaver. The beaver is reserved for the finer hats. The fur is first laid upon a hurdle made of wood or wire, with longitudinal openings; and the operator, by means of an instrument called the bow (which is a piece of elastic ash, six or seven feet long, with a catgut stretched between its two extremities, and made to vibrate by a bowstick), causes the vibrating string to strike and play upon the fur, so as to scatter the fibres in all directions, while the dust and filth descend through the grids of the hurdle.

After the fur is thus driven by the bow from the one end of the hurdle to the other, it forms a mass called a *bat*, which is only half the quantity sufficient for a hat. The bat or *capade* thus formed is rendered compact by pressing it down with the *hardening skin* (a piece of half-tanned leather), and the union of the fibres is increased by covering them with a cloth, while the workman presses them together repeatedly with his hands. The cloth being taken off, a piece of paper, with its corners doubled in, so as to give it a triangular outline, is laid above the bat. The opposite edges of the bat are then folded over the paper, and being brought together and pressed again with the hands, they form a conical cap. This cap is next laid upon another bat, ready hardened, so that the joined

edges of the first bat rest upon the new one. This new bat is folded over the other, and its edges joined by pressure as before; so that the joining of the first conical cap is opposite to that of the second. This compound bat is now wrought with the hands for a considerable time upon the hurdle between folds of linen cloth, being occasionally sprinkled with clear water, till the hat is basined or rendered tolerably firm.

The cap is now taken to a wooden receiver, like a very flat mill-hopper, consisting of eight wooden planes, sloping gently to the centre, which contains a kettle filled with water acidulated with sulphuric acid. The technical name of this vessel is the *battery*. It consists of a kettle A; and of the planks, B C, which are sloping planes, usually eight in number, one being allotted to each workman. The half of each plank next the kettle is made of lead, the upper half of mahogany. In this liquor the hat is occasionally dipped, and wrought by the hands, or sometimes with a roller, upon the sloping planks. It is thus fulled or thickened during four or five hours; the knots or hard substances are picked out by the workman, and fresh felt is added by means of a wet brush to those parts that require it. The beaver is applied at the end of this operation. In the manufacture of beaver hats, the grounds of beer are added to the liquor in the kettle.
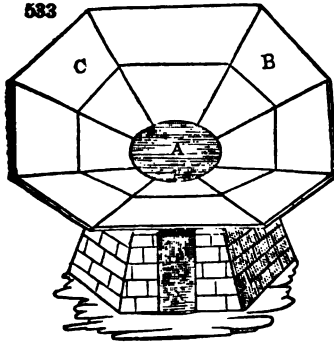
Stopping, or thickening the thin spots, seen by looking through the body, is performed by daubing on additional stuff with successive applications of the hot acidulous liquor from a brush dipped into the kettle, until the body be sufficiently shrunk and made uniform. After drying, it is stiffened with varnish composition rubbed in with a brush; the inside surface being more copiously imbued with it than the outer; while the brim is peculiarly charged with the stiffening.

When once more dried, the body is ready to be *covered*, which is done at the *battery*. The first cover of beaver or napping, which has been previously *bowed*, is strewed equably over the body, and patted on with a brush moistened with the hot liquor, until it gets incorporated; the cut ends towards the root, being the points which spontaneously intrude. The body is now put into a coarse hair cloth, then dipped and rolled in the hot liquor, until the root ends of the beaver are thoroughly worked in. This is technically called *rolling off*, or *roughing*. A strip for the brim, round the edge of the inside, is treated in the same way; whereby every thing is ready for the second cover (of beaver), which is incorporated in like manner; the rolling, &c. being continued, till a uniform, close, and well-felted hood is formed.

The hat is now ready to receive its proper shape. For this purpose the workman turns up the edge or brim to the depth of about 1½ inch, and then returns the point of the cone back again through the axis of the cap, so as to produce another inner fold of the same depth. A third fold is produced by returning the point of the cone, and so on till the point resembles a flat circular piece having a number of concentric folds. In this state it is laid upon the plank, and wetted with the liquor. The workman pulls out the point with his fingers, and presses it down with his hand, turning it at the same time round on its centre upon the plank, till a flat portion, equal to the crown of the hat, is rubbed out. This flat crown is now placed upon a block, and, by pressing a string called a *commander*, down the sides of the block, he forces the parts adjacent to the crown, to assume a cylindrical figure. The brim now appears like a puckered appendage round the cylindrical cone; but the proper figure is next given to it, by working and rubbing it. The body is rendered waterproof and stiff by being imbued with a varnish composed of shellac, sandarach, mastic, and other resins dissolved in alcohol or naptha.

The hat being dried, its nap is raised or loosened with a wire brush or card, and sometimes it is previously pounced or rubbed with pumice, to take off the coarser parts, and afterwards rubbed over with seal-skin. The hat is now tied with pack-thread upon its block, and is afterwards dyed. See HAT-DYEING, *infra*.

The dyed hats are now removed to the stiffening shop. Beer grounds are next applied on the inside of the crown, for the purpose of preventing the glue from coming through; and when the beer grounds are dried, glue (gum Senegal is sometimes used) a little thinner than that used by carpenters, is laid with a brush on the inside of the crown, and the lower surface of the brim.

The bat is then softened by exposure to steam, on the steaming basin, and is brushed and ironed till it receives the proper gloss. It is lastly cut round at the brim by a knife fixed at the end of a gauge, which rests against the crown. The brim, however, is not

cut entirely through, but is torn off so as to leave an edging of beaver round the external
rim of the hat.   The crown being tied up in a gauze paper, which is neatly ironed
down, is then ready for the last operations of lining and binding.

The furs and wools of which hats are manufactured contain, in their early stage of prep-
aration, *hemps* and *hairs*, which must be removed in order to produce a material for the
better description of hats.   This separation is effected by a sort of winnowing machine,
which wafts away the finer and lighter parts of the furs and wools from the coarser.
Messrs. Parker and Harris obtained a patent in 1822 for the invention and use of such
an apparatus, whose structure and functions may be perfectly understood, from its analogy
to the blowing and scutching machine of the cotton manufacture; to which I therefore
refer my readers.

I shall now proceed to describe some of the recent improvements proposed in the man-
ufacture of hats, but their introduction is scarcely possible, on account of the perfectly
organized combination which exists among journeyman hatters throughout the kingdom,
by which the masters are held in a state of complete servitude, having no power to take a
single apprentice into their works beyond the number specified by the *Union*, nor any sort
of machine which is likely to supersede hand labor in any remarkable degree.   Hence
the hat trade is, generally speaking, unproductive to the capitalist, and incapable of re-
ceiving any considerable development.   The public of a free country like this, ought to
counteract this disgraceful state of things, by renouncing the wear of stuff hats, a branch
of the business entirely under the control of this despotic *Union*, and betake themselves
to the use of silk hats, which, from recent improvements in their fabric and dyeing, are
not a whit inferior to the beaver hats, in comfort, appearance, or durability, while they
may be had of the best quality for one fourth part of their price.

The annexed figures represent Mr. Ollerenshaw's machine, now generally employed
or ironing hats.   *Fig.* 534 is the frame-work or standard upon which three of these
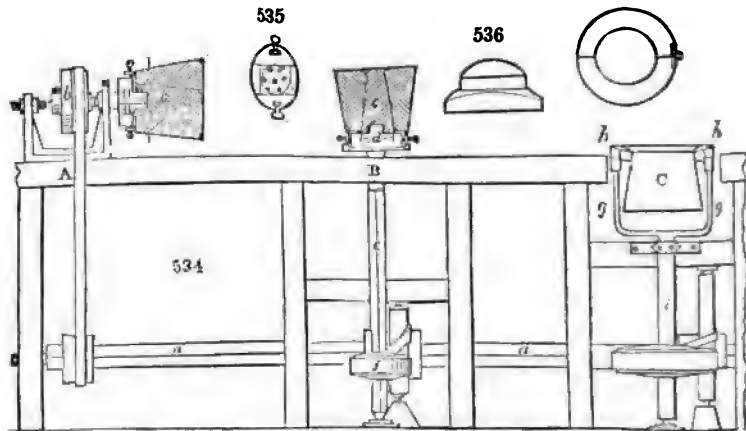
lathes are mounted, as A, B, C.   The lathe A is intended to be employed when the
crown of the hat is to be ironed.   The lathe B, when the flat top, and the upper side of
the brim is ironed, and lathe C, when its under side is ironed ; motion being given to the
whole by means of a band passing from any first mover (as a steam-engine, water-wheel,
&c.) to the drum on the main shaft *a a*.   From this drum a strap passes over the rigger
b, which actuates the axle of the lathe A.   On to this lathe a sort of chuck is screwed, and
to the chuck the block *c* is made fast by screws, bolts, or pins.   This block is represent-
ed in section, in order to show the manner in which it is made, of several pieces held
fast by the centre wedge-piece, as seen at *fig.* 535.

The hat-block being made to turn round with the chuck, at the rate of about twenty
turns per minute, but in the opposite direction to the revolution of an ordinary turning
lathe, the workman applies his hot iron to the surface of the hat, and thereby smooths
it, giving a beautiful glossy appearance to the beaver; he then applies a plush cushion,
and rubs round the surface of the hat while it is still revolving.   The hat, with its
block, is now removed to the lathe B, where it is placed upon the chuck *d*, and made to
turn in a horizontal direction, at the rate of about twenty revolutions per minute, for
the purpose of ironing the flat-top of the crown.   This lathe B moves upon an upright
shaft *e*, and is actuated by a twisted band passing from the main shaft, round the

rigger *f*. In order to iron the upper surface of the brim, the block *c* is removed from the lathe, and taken out of the hat, when the block *fig.* 536, is mounted upon the chuck *d*, and made to turn under the hand of the workman, as before.

The hat is now to be removed to the lathe c, where it is introduced in an inverted position, between the arms *g g* supporting the rim *h h*, the top surface of which is shown at *fig.* 537. The spindle *i* of the lathe turns by similar means to the last, but slower; only ten turns per minute will be sufficient. The workman now smooths the under side of the brim, by drawing the iron across it, that is, from the centre outwards. The hat is then carefully examined, and all the burs and coarse hairs picked out, after which the smoothing process is performed as before, and the dressing of the hat is complete.

Messrs. Gillman and Wilson, of Manchester, obtained a patent in 1823, for a peculiar kind of fabric to be made of cotton, or a mixture of cotton and silk, for the covering of hats and bonnets, in imitation of beaver. The foundation of the hat may be of felt, hemp, wool, which is to be covered by the patent fabric. This debased article does not seem to have got into use; cotton, from its want of the felting property and inelasticity, being very ill-adapted for making hat-stuff.

A more ingenious invention of John Gibson, hatter, in Glasgow, consisting of an elastic fabric of whalebone, was made the subject of a patent, in June, 1824. The whalebone, being separated into threads no larger than hay stalks, is to be boiled in some alkaline liquid for removing the oil from it, and rendering it more elastic. The longest threads are to be employed for warp, the shorter for weft; and are to be woven in a hair-cloth loom. This fabric is to be passed between rollers, after which it is fit to be cut out into forms for making hats and bonnets, to be sewed together at the joints, and stiffened with a preparation of resinous varnishes, to prevent its being acted upon by perspiration or rain. A very considerable improvement in the lightness and elasticity of silk hats has been the result of this invention.

The foundation of men's hats, upon whose outside the beaver, down, or other fine fur is laid to produce a nap, is, as I have described, usually made of wool felted together by hand, and formed first into conical caps, which are afterwards stretched and moulded upon blocks to the desired shape. Mr. Borradaile, of Bucklersbury, obtained a patent in November, 1825, for a machine, invented by a foreigner, for setting up hat bodies, which seems to be ingeniously contrived; but I shall decline describing it, as it has probably not been suffered by the *Union* to come into practical operation, and as I shall presently give the details of another later invention for the same purpose.

Silk hats, for several years after they were manufactured, were liable to two objections; first, the body or shell over which the silk covering is laid, was, from its hardness, apt to hurt the head; second, the edge of the crown being much exposed to blows, the silk nap soon got abraded, so as to lay bare the cotton foundation, which is not capable of taking so fine a black dye as the silk; whence the hat assumed a shabby appearance. Messrs. Mayhew and White of London, hat-manufacturers, proposed in their patent of February, 1826, to remedy these defects, by making the hat body of stuff or wool, and relieving the stiffness of the inner part round the brim, by attaching a coating of beaver upon the under side of the brim, so as to render the hat pliable. Round the edge of the tip or crown, a quantity of what is called stop wool is to be attached by the ordinary operation of bowing, which will render the edge soft and elastic. The hat is to be afterwards dyed of a good black color, both outside and inside; and being then properly stiffened and blocked, is ready for the covering of silk.

The plush employed for covering silk hats, is a raised nap or pile woven usually upon a cotton foundation; and the cotton, being incapable of receiving the same brilliant black dye as the silk, renders the hat apt to turn brown whenever the silk nap is partially worn off. The patentees proposed to counteract this evil, by making the foundation of the plush entirely of silk. To these two improvements, now pretty generally introduced, the present excellence of the silk hats may be, in a good measure, ascribed.

The apparatus above alluded to, for making the foundations of hats by the aid of mechanism, was rendered the subject of a patent, by Mr. Williams, in September, 1826; but I fear it has never obtained a footing, nor even a fair trial in our manufactures, on account of the hostility of the operatives to all labor-saving machines.

Fig. 538 is a side view of the carding engine, with a horizontal or plan view of the lower part of the carding machine, showing the operative parts of the winding apparatus, as connected to the carding engine. The doffer cylinder is covered with fillets of wire cards, such as are usually employed in carding engines, and these fillets are divided into two, three, or more spaces extending round the periphery of the cylinder, the object of which division is to separate the sliver into two, three, or more breadths, which are to be conducted to, and wound upon distinct blocks, for making so many separate hats or caps.

The principal cylinder of the carding engine is made to revolve by a rigger upon its axle, actuated by a band from any first mover as usual, and the subordinate rollers or
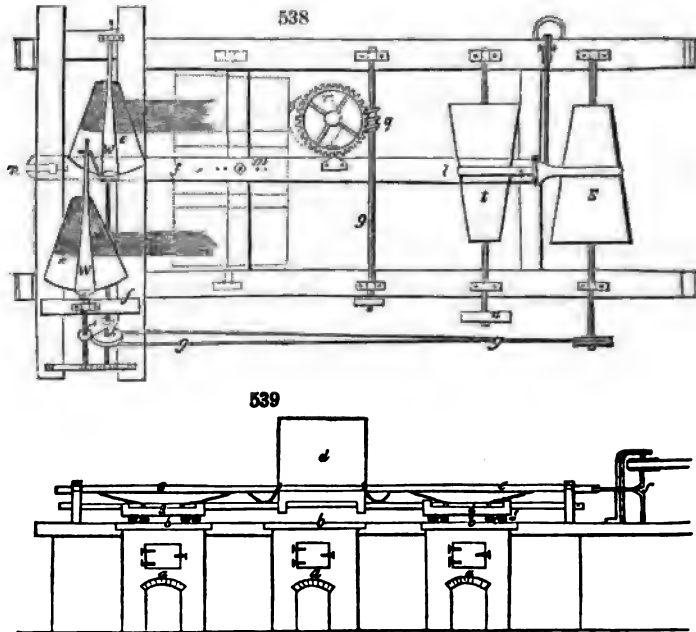
cylinders belonging to the carding engine, are all turned by pulleys, and bands, and gear, as in the ordinary construction.

The wool or other material is supplied to the feeding cloth, and carried through the engine to the doffer cylinder, as in other carding engines; the doffer comb is actuated by a revolving crank in the common way, and by means of it the slivers are taken from the doffer cylinder, and thence received on to the surfaces of the blocks *e e*. These blocks, of which two only are shown to prevent confusion, are mounted upon axles, supported by suitable bearings in a carriage *f f*, and are made to revolve by means of a band *g g*, leading from a pulley on the axle of a conical drum beneath. The band *g* passes over a pulley *h*, affixed to the axle of one of the blocks, while another pulley *i*, upon the same axle, gives motion, by means of a band, to as many other blocks as are adapted to the machine.

As it is necessary, in winding the slivers on to the blocks, to cross them in different directions, and also to pass the sliver over the hemispherical ends of the blocks, in order that the wool or other material may be uniformly spread over the surface in forming the cap or hood for the shell or foundation of the intended hat, the carriage *f*, with the blocks, is made to traverse to and fro in lateral directions upon rollers at each end.

This alternating motion of the carriage is caused by a horizontal lever *l l* (seen in the horizontal view *fig.* 538), moving upon a fulcrum pin at *m*, which lever is attached to the carriage at one extremity *n*, and at the other end has a weighted cord which draws the side of this lever against a cam wheel *o*. This cam is made to revolve by means of a band and pulley, which turns the shaft and endless screw *q*, and this endless screw taking into a toothed wheel *r*, on the axle of the cam *o*, causes the cam to revolve, the periphery of which cam running against a friction roller on the side of the lever *l*, causes the lever to vibrate, and the carriage *f f* attached to it, to traverse to and fro upon the supporting rollers, as described. By these means the slivers are laid in oblique directions (varying as the carriage traverses), over the surface of the blocks.

The blocks being conically formed, or of other irregular figures, it is necessary, in order to wind the slivers with uniform tension, to vary their speed according to the diameter of that part of the block which is receiving the sliver. This is effected by giving different velocities to the pulley on the axle of the conical drum *s*, corresponding with *e*. There is a similar conical drum *t*, placed in a reverse position in the lower

frame, which is actuated by a band from any convenient part of the machine
r a pulley *u*, upon the axle of *t*. From the drum *t*, to the drum *s*, there is a
ch is made to slide along the drums by the guidance of two rollers at the end
·*L*

w be seen that when the larger diameter of the cam wheel *o* forces the lever
ie band *v* will be guided on to the smaller part of the conical drum *t* and the
of *s*, consequently the drum *s* will at this time receive its slowest motion, and
will turn the blocks slower also; the reverse end of the lever *l* having, by the
ient, slidden the carriage into that position which causes the slivers to wind
·ger diameter of the blocks.
: smaller diameter of the cam is acting against the side of the lever, the
ird draws the end of the lever to the opposite side, and the band *v* will be
i the larger part of the cord *t*, and the smaller part of the cone *s*; consequently,
movement of the band *g* will now cause the blocks *e e* to revolve with a cor-
speed. The carriage *f* will also be moved upon its rollers, to the reverse side,
·er of wool or other material be now wound upon the smaller parts and ends
is, at which time the quicker rotation of the blocks is required. It may be
ed, that the cam wheel *o* should be differently formed according to the differ-
blocks employed, so as to produce the requisite movements of the lever and
ted thereto.
:mains to state, that there are two heavy conical rollers *w w*, bearing upon
·ries of the blocks *e e*, which turn loosely upon their axles by the friction
for the purpose of pressing the slivers of wool·or other material on the
comes from the doffer cylinder of the carding engine, and when the blocks
:oated with a sufficient quantity of the sliver, the smaller end of the pressing
be raised, while the cap is withdrawn from the block. The process being
s before, the formation of other bodies or caps is effected in the manner above

caps or bodies of hats, &c. are formed in the above described machine, they
n wet cloths, and placed upon heated plates, where they are rolled under
r the purpose of being hardened. *Fig.* 539 represents the front of three
s *a*, the tops of which are covered with iron plates *b b b*. Upon these plates,
heated by the furnace below, or by steam, the bodies wrapped in the wet
:, are placed, and pressed upon by the flaps or covers *d d d*, sliding upon
to which flaps a traversing motion is given, by means of chains attached to
ng bar *e e*. This bar is moved by a rotatory crank *f*, which has its motion
from any actuating power. When any one of the flaps is turned up to
: bodies from beneath, the chains hang loosely, and the flap remains

ps or hat bodies, after having been hardened in the manner above described,
:d in the usual way by hand, or they are felted in a fulling mill, by the usual
ployed for milling cloths, except that the hat bodies are occasionally taken out
g mill, and passed between rollers, for the purpose of rendering the felt more

543
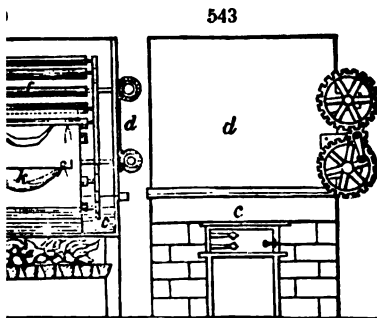
Mr. Carey, of Basford, ob-
tained a patent in October, 1834,
for an invention of certain ma-
chinery to be employed in the
manufacture of hats, which is
ingenious, and seems to be worthy
of notice in this place. It con-
sists in the adaptation of a sys-
tem of rollers, forming a machine,
by means of which the operation
of roughing or plaiting of hats
may be performed; that is, the
beaver or other fur may be made
to attach itself, and work into
the felt or hat body, without the
necessity of the ordinary manual
operations.

mpanying drawings represent the machine in several views, for the purpose
the construction of all its parts. *Fig.* 540 is a front elevation of the machine;
a side elevation of the same; *fig.* 542 is a longitudinal section of the ma-
fig. 543 is a transverse section; the similar letters indicating the same parts
gures.

Upon a brick or other suitable base, a furnace or fire-place *a*, is made, having a descending flue *b*, for the purpose of carrying away the smoke. A pan or shallow vessel *c c*, formed of lead, is placed over the furnace; which vessel is intended to contain a sour liquor, as a solution of vitriolic acid and water. On the edge of this pan is erected a wooden casing *d d d*, which encloses three sides, leaving the fourth open for the purpose of obtaining access to the working apparatus within. A series of what may be termed lantern rollers, *e e e*, is mounted on axles turning in the side casings; and another series of similar lantern rollers, *f f f*, is in like manner mounted above. These lantern rollers are made to revolve by means of bevel pinions, fixed on the ends of their axles, which are turned by similar bevel wheels on the lateral shafts *g* and *h*, driven by a winch *i*, and gear, as shown in figs. 540 and 541.
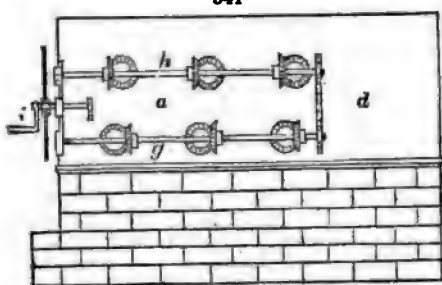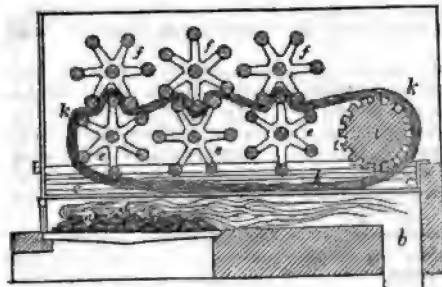
Having prepared the bodies of the hats, and laid upon their surfaces the usual coatings of beaver, or other fur, when so prepared they are to be placed between hair cloths, and these hair cloths folded within a canvass or other suitable wrapper. Three or more hats being thus enclosed in each wrapper, the packages are severally put into bags or pockets in an endless band of sackcloth, or other suitable material; which endless band is extended over the lantern rollers in the machine.

In the first instance, for the purpose of merely attaching the furs to the felts (which is called slicking, when performed by hand), Mr. Carey prefers to pass the endless band *k k k*, with the covered hat bodies, over the upper series *f f f*, of the lantern rollers, in order to avoid the inconvenience of disturbing the fur, which might occur from subjecting them to immersion in the solution contained in the pan, before the fur had become attached to the bodies.

After this operation of slicking has been effected, he distends the endless band *k k k*, over the lower series of lantern rollers *e e e*, and round a carrier roller *l*, as shown in fig 542; and having withdrawn the hat bodies for the purpose of examining them, and changing their folds, he packs them again in a similar way in flannel, or other suitable cloths, and introduces them into the pockets or bags of the endless bands, as before.

On putting the machinery in rotatory motion in the way described, the hats will be carried along through the apparatus, and subjected to the scalding solution in the pan, as also to the pressure, and to a tortuous action between the ribs of the lantern rollers, as they revolve, which will cause the ends of the fur to work into the felted bodies of the hats, and by that means permanently to attach the nap to the body; an operation which, when performed by hand, is called rolling off.

The improved stiffening for hat bodies proposed by Mr. Blades, under his patent of January, 1828, consists in making his solution of shellac in an alkaline ley, instead of spirits of wine, or pyroxylic spirit, vulgarly called naptha.

He prepares his water-proof stiffening by mixing 18 pounds of shellac with 1½ pounds of salt of tartar (carbonate of potash), and 5¼ gallons of water. These materials are to be put into a kettle, and made to boil gradually until the lac is dissolved; when the liquor will become as clear as water, without any scum upon the top, and if left to cool, will have a thin crust upon its surface of a whitish cast, mixed with the light impurities of the gum. When this skin is taken off, the hat body is to be dipped into the mixture in a cold state, so as to absorb as much as possible of it; or it may be applied with a brush or sponge. The hat body, being thus stiffened, may stand till it become dry, or nearly so; and after it has been brushed, it must be immersed in very dilute sulphuric or acetic acid, in order to neutralize the potash, and cause the shellac to

set. If the hats are not to be napped immediately, they may be thrown into a cistern of pure water, and taken out as wanted.

Should the hat bodies have been worked at first with sulphuric acid (as usual), they must be soaked in hot water to extract the acid, and dried before the stiffening is applied: care being taken that no water falls upon the stiffened body, before it has been immersed in the acid.

This ingenious chemical process has not been, to the best of my knowledge, introduced into the hat manufacture. A varnish made by dissolving shellac, mastic, sandarach, and other resins in alcohol, or the naptha of wood vinegar, is generally employed as the stiffening and water-proof ingredient of hat bodies. A solution of caoutchouc is often applied to whalebone and horse-hair hat bodies.

The following recipe has been prescribed as a good composition for stiffening hats; four parts of shellac, one part of mastic, one half of a part of turpentine, dissolved in five parts of alcohol, by agitation and subsequent repose, without the aid of heat. This stiffening varnish should be applied quickly to the body or foundation with a soft oblong brush, in a dry and rather warm workshop; the hat being previously fitted with its inside turned outwards upon a block. The body must be immediately afterwards taken off, to prevent adhesion.

Hat-Dyeing.—The ordinary bath for dyeing hats, employed by the London manufacturers, consists, for 12 dozen, of—

> 144 pounds of logwood;
> 12 pounds of green sulphate of iron, or copperas;
> 7½ pounds of verdigris.

The copper is usually made of a semi-cylindrical shape, and should be surrounded with an iron jacket or case, into which steam may be admitted, so as to raise the temperature of the interior bath to 190° F., but no higher, otherwise the heat is apt to affect the stiffening varnish, called the gum, with which the body of the hat has been imbued. The logwood having been introduced and digested for some time, the copperas and verdigris are added in successive quantities, and in the above proportions, along with every successive two or three dozens of hats, suspended upon the dipping machine. Each set of hats, after being exposed to the bath with occasional airings during 40 minutes, is taken off the pegs, and laid out upon the ground to be more completely blackened by the peroxydizement of the iron with the atmospheric oxygen. In 3 or 4 hours the dyeing is completed. When fully dyed, the hats are well washed in running water.

Mr. Buffum states that there are four principal objects accomplished by his patent invention for dyeing hats.

1. in the operation;
2. the production of a better color;
3. the prevention of any of the damages to which hats are liable in the dyeing;
4. the accomplishment of the dyeing process in a much shorter time than by the usual methods, and consequently lessening the injurious effects of the dye-bath upon the texture of the hat.

Fig. 544 shows one method of constructing the apparatus. *a a* is a semi-cylindrical

544   545
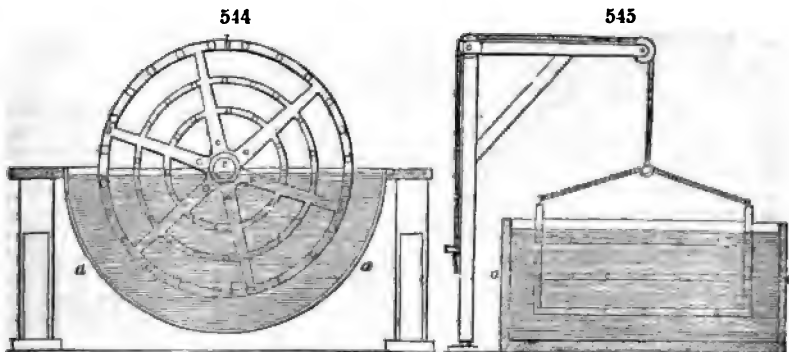
shaped copper vessel, with flat ends, in which the dyeing process is carried on. *b b b* is a wheel with several circular rims mounted upon arms, which revolve upon an axle *c*. In the face of these rims a number of pegs or blocks are set at nearly equal distances apart, upon each of which pegs or blocks it is intended to place a hat, and as the wheel

revolves, to pass it into and out of the dyeing liquor in the vat or copper. This wheel may be kept revolving with a very slow motion, either by gear connecting its axle, c, with any moving power, or it may be turned round by hand, at intervals of ten minutes; whereby the hats hung upon the pegs, will be alternately immersed for the space of ten minutes in the dyeing liquor, and then for the same space exposed to the atmospheric air. In this way, the process of dyeing, it is supposed, may be greatly facilitated and improved, as the occasional transition from the dye vat into the air, and from the air again into the bath, will enable the oxygen of the atmosphere to strike the dye more perfectly and expeditiously into the materials of which the hat is composed, than by a continued immersion in the bath for a much longer time.

A variation in the mode of performing this process is suggested, and the apparatus *fig.* 545 is proposed to be employed. *a a* is a square vat or vessel containing the dyeing liquor; *b b* is a frame or rack having a number of pegs placed in it for hanging the hats upon, which are about to be dyed, in a manner similar to the wheel above described. This frame or rack is suspended by cords from a crane, and may in that way be lowered down with the hats into the vat, or drawn up and exposed in the air; changes which may be made every 10 or 20 minutes.

I have seen apparatus of this kind doing good work in the hat-dyeing manufactories of London, that being a department of the business with which the Union has not thought it worth their while to interfere.

Mr. William Hodge's patent improvements in hat dyeing, partly founded upon an invention of Mr. Bowler, consist, first in causing every alternate frame to which the suspenders or blocks are to be attached, to slide in and out of grooves, for the purpose

546   546   547
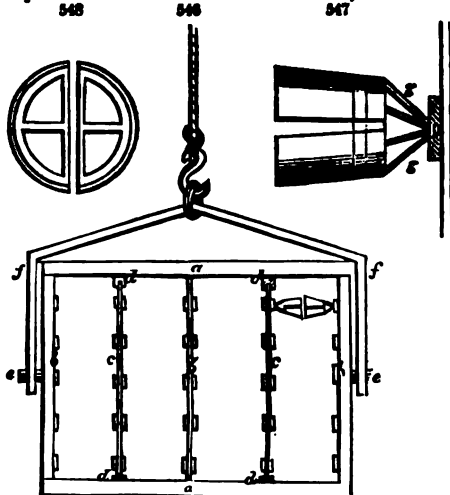
of more easily removing the said suspenders when required. *Fig.* 546 represents the improved dyeing frame, consisting of two circular rims, *a a*, which are connected together at top and bottom, by three fixed perpendicular bars or the frame-work *b b b*. Two other perpendicular frames *c c*, similar to the former, slide in grooves, *d d d d*, fixed to the upper and lower rims. These grooves have anti-friction rollers in them, for the purpose of making the frames *c c*, to slide in and out more freely. The suspenders or substitutes for blocks, by these means, may be more easily got at by drawing out the frames *c c*, about half way, when the suspenders, which are attached to the frames with the hats upon them, may be easily reached, and either removed or altered in position:

and when it is done on one side, the sliding frame may be brought out on the other, and the remaining quantity of "suspenders" undergo the same operation.

The patentee remarks, that it is well known to all hat dyers, that after the hats have been in the dyeing liquor some time, they ought to be taken out and exposed to the action of the atmospheric air, when they are again immersed in the copper, that part of the hat which was uppermost in the first immersion, being placed downwards in the second. This is done for the purpose of obtaining a uniform and regular dye. The patentee's mode of carrying this operation into effect, is shown in the figure: *e e* are pivots for the dyeing-frame to turn upon, which is supported by the arms *f*, from a crane above. The whole apparatus may be raised up or lowered into the copper by means of the crane or other mechanism. When the dyeing-frame is raised out of the copper, the whole of the suspenders or blocks are reversed, by turning the apparatus over upon the pivots *e e*, and thus the whole surfaces of the hats are equally acted upon by the dyeing material.

It should be observed, that when the dyeing-frame is raised up out of the copper, it should be tilted on one side, so as to make all the liquor run out of the hats, as also to cause the rims of the hats to hang down, and not stick to the body of the hat, or leave a bad place or uneven dye upon it. The second improvement described by the patentee, is the construction of "suspenders," to be substituted instead of the ordinary blocks.

These "suspenders" are composed of thin plates of copper, bent into the required form, that is, nearly resembling that of a hat block, and made in such a manner as to be capable of contraction and expansion to suit different sized hats, and keep them distended, which may be altered by the workmen at pleasure, when it is required to place the hats upon them, or remove them therefrom. The dyeing-frame at *fig.* 546 is shown with only two of these "suspenders," in order to prevent confusion. One of these suspenders is represented detached at *fig.* 547, which exhibits a side view; and *fig.* 548 a front view of the same. It will be seen by reference to the figure, that the suspenders consist of two distinct parts, which may be enlarged or collapsed by a variety of means, and which means may be suggested by any competent mechanic. The two parts of the suspenders are proposed to be connected together by arms *g g*, and at the junction of these arms a key is connected for turning them round when required. It will be seen on reference to the front view, *fig.* 548, that the "suspenders" or substitutes for blocks, are open at the top or crown part of the hat; this is for the purpose of allowing the dyeing liquor to penetrate.

From the mixture of copperas and verdigris employed in the hat-dye, a vast quantity of an ochreous muddy precipitate results, amounting to no less than 25 per cent. of the weight of the copperas. This iron mud forms a deposite upon the hats, which not only corrodes the fine filaments of the beaver, but causes both them and the felt stuff to turn speedily of a rusty brown. There is no process in the whole circle of our manufactures so barbarous as that of dyeing stuff hats. No ray of chemical science seems hitherto to have penetrated the dark recesses of their dye shops. Some hatters have tried to remove this corrosive brown ochre by a bath of dilute sulphuric acid, and then counteract the evil effect of the acid upon the black dye by an alkaline bath; but with a most unhappy effect. Hats so treated are most deceptious and unprofitable; as they turn of a dirty brown hue, when exposed for a few weeks to sunshine and air.

HEALDS, is the harness for guiding the warp threads in a loom; that is, for lifting a certain number of them alternately to open the shed, and afford passage to the decussating weft threads of the shuttle. See WEAVING.

HEARTH (*Foyer*, Fr.; *Heerde*, Germ.) is the flat or hollow space in a smelting furnace upon which the ore and fluxes are subjected to the influence of flame. See COPPER, IRON, METALLURGY, &c.

HEAT, is that power or essence called caloric, the discussion of whose habitudes with the different kinds of matter belongs to the science of chemistry.

HEAT-REGULATOR. The name given by M. Bonnemain to an ingenious apparatus for regulating the temperature of his incubating stove rooms. See INCUBATION, ARTIFICIAL, for the manner of applying the Heat-Regulator.

The construction of the regulator is founded upon the unequal dilatation of different metals by the same degree of heat. A rod of iron *x*, *fig.* 549, is tapped at its lower

549

549°
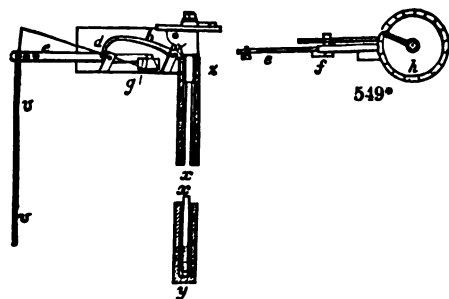
end into a brass nut *y*, enclosed in a leaden box or tube, terminated above by a brass collet *z*. This tube is plunged into the water of the boiler, alongside of the smoke-pipe. (*Fig.* 549° is a bird's-eye view of the dial, &c.) The expansion of the lead being more than the iron for a like degree of temperature, and the rod enclosed within the tube being less easily warmed, whenever the heat rises to the desired pitch, the elongation of the tube puts the collet *z* in contact with the heel *a*, of the bent lever *a*, *b*, *d*; thence the slightest increase of heat lengthens the tube anew, and the collet lifting the heel of the lever depresses its other end *d* through a much greater space, on account of the relative lengths of its legs. This movement operates near the axis of a balance-bar *e*, sinks one end of this, and thereby increases the extent of the movement which is transmitted directly to the iron skewer *v*. This pushing down a swing register diminishes or cuts off the access of air to the fire-place. The combustion is thereby obstructed, and the temperature falling by degrees, the tube shrinks and disengages the heel of the lever. The counterpoise *g*, fixed to the balance beam *e*, raises the other extremity of this beam, by raising the end *d* of the lever as much as is necessary to make the heel bear upon the collet of the tube. The swing register acted upon by this means, presents a greater section to the passage of the air; whence the combustion is increased. To counter-

balance the effect of atmospheric changes, the iron stem which supports the regulator is terminated by a dial disc, round the shaft of the needle above h, *fig.* 549°; on turning this needle the stem below it turns, as well as a screw at its under end, which raises or lowers the leaden tube. In the first case, the heel falls, and opens the swing register, whence a higher temperature is required to shut it, by the expansion of the tube. We may thus obtain a regularly higher temperature. If, on the contrary, we raise the tube by turning the needle in the other direction, the register presents a smaller opening, and shuts at a lower temperature; in this case, we obtain a regularly lower temperature. It is therefore easy, says M. Bonnemain, to determine *à priori* the degree of temperature to be given to the water circulating in the stove pipes. In order to facilitate the regulation of the apparatus, he graduated the disc dial, and inscribed upon its top and bottom the words, Strong and Weak heat. See THERMOSTAT, for another HEAT-REGULATOR.

HEAVY SPAR, *sulphate of Baryta, or Cawk (Spath pesant,* Fr.; *Schwerspath,* Germ.), is an abundant mineral, which accompanies veins of lead, silver, mercury, &c., but is often found, also, in large masses. Its color is usually white, or flesh-colored. It occurs in many crystalline forms, of which the cleavage is a right rhomboidal prism. It is met with also of a fibrous, radiated, and granular structure. Its spec. grav. varies from 4·1 to 4·6. It has a strong lustre, between the fatty and the vitreous. It melts at 35° Wedgew. into a white opaque enamel. Its constituents are 65·63 baryta, and 34·37 sulphuric acid. It is decomposed by calcination in contact with charcoal at a white heat, into sulphuret of baryta; from which all the baryta salts may be readily formed. Its chief employment in commerce is for adulterating white lead; a purpose which it readily serves on account of its density. Its presence here is easily detected by dilute nitric acid, which dissolves the carbonate of lead, and leaves the heavy spar. It is also a useful ingredient in some kinds of pottery and glass.

HECKLE (*Seran,* Fr.; *Hechel,* Germ.) is an implement for dissevering the filaments of flax, and laying them in parallel stricks or tresses. See FLAX.

HELIOTROPE is a variety of jaspar, mixed with chlorite, green earth, and diallage; occasionally marked with blood-red points; whence its vulgar name of *blood-stone.*

HEMATINE is the name given by its discoverer Chevreul to a crystalline substance, of a pale pink color, and brilliant lustre when viewed in a lens, which he extracted from logwood, the *hæmatoxylon Campechianum* of botanists. It is, in fact, the characteristic principle of this dye-wood. To procure hematine, digest during a few hours ground logwood in water heated to a temperature of about 130° F.; filter the liquor, evaporate it to dryness by a steam bath, and put the extract in alcohol of 0·835 for a day. Then filter anew, and after having inspissated the alcoholic solution by evaporation, pour into it a little water, evaporate gently again, and then leave it to itself in a cool place. In this way a considerable quantity of crystals of hematine will be obtained, which may be readily purified by washing with alcohol and drying.

When subjected to dry distillation in a retort, hematine affords all the usual products of vegetable bodies, along with a little ammonia; which proves the presence of azote. Boiling water dissolves it abundantly, and assumes an orange-red color, which passes into yellow by cooling, but becomes red again with heat. Sulphurous acid destroys the color of solution of hematine. Potash and ammonia convert into a dark purple-red tint, the pale solution of hematine; when these alkalis are added in large quantity, they make the color violet blue, then brown-red, and lastly brown-yellow. By this time, the hematine has become decomposed, and cannot be restored to its pristine state by neutralizing the alkalis with acids.

The waters of baryta, strontia, and lime exercise an analogous power of decomposition; but they eventually precipitate the changed coloring matter.

A red solution of hematine subjected to a current of sulphureted hydrogen becomes yellow; but it resumes its original hue when the sulphureted hydrogen is removed by a little potash.

The protoxyde of lead, the protoxyde of tin, the hydrate of peroxyde of iron, the hydrate of oxydes of copper and nickel, oxyde of bismuth, combine with hematine, and color it blue with more or less of a violet cast.

Hematine precipitates glue from its solution in reddish flocks. This substance has not hitherto been employed in its pure state; but as it constitutes the active principle of logwood, it enters as an ingredient into all the colors made with that dye stuff.

These colors are principally violet and black. Chevreul has proposed hematine as an excellent test of acidity.

HEMATITE (*Fer Oligiste,* Fr.; *Rotheisenstein,* Germ.) is a native reddish-brown peroxyde of iron, consisting of oxygen 30·66; iron 60·34. It is the kidney ore of Cumberland, which is smelted at Ulverstone with charcoal, into excellent steel iron.

HEMP (*Chanvre,* Fr.; *Hanf,* Germ.) is the fibrous rind of the bark of the *canna-*

bis sativa, which is spun into strands or yarn for making ropes, sail-cloth, &c. It is prepared for spinning in the same way as flax, which see. *Hemp-seed* contains an oil which is employed for making soft soap, for painting, and for burning in lamps. See OILS.

Importation of undressed hemp for home consumption; and amount of duty, in

1837.	1838.	1837.	1838.
Cwts. 596,994·3.	667,017.	£2487.	£2780

HEPAR, which signifies liver in Latin, was a name given by the older chemists to some of those compounds of sulphur with the metals which had a liver-brown color. Thus the sulphuret of potassium was called liver of sulphur.

HEPATIC AIR; sulphureted hydrogen gas.

HERMETICAL SEAL, is an expression derived from Hermes, the fabulous parent of Egyptian chemistry, to designate the perfect stoppage of a hollow vessel, by the cementing or melting of the lips of its orifice; as in the case of a glass thermometer, or matrass.

HIDE (*Peau*, Fr.; *Haut*, Germ.), the strong skin of an ox, horse, or other large animal. See LEATHER.

Importation of untanned hides for home consumption; and amount of duty, in

1837.	1838.	1837.	1838.
332,877.	301,890.	£46,190.	£36,647.

HIRCINE; from *hircus*, a ram; is the name given by Chevreul to a liquid fatty substance, which is mixed with the oleine of mutton suet, and gives it its peculiar rank smell. Hircine is much more soluble in alcohol than oleine. It produces *hircic* acid by saponification.

HOG'S LARD; see FATS.

HONEY (*Mel*, Fr.; *Honig*, Germ.) is a sweet viscid liquor, elaborated by bees from the sweet juices of flowers, and deposited by them in the waxen cells of their combs. Virgin honey is that which spontaneously flows with a very gentle heat from the comb, and common honey is that which is procured by the joint agency of pressure and heat. The former is whitish or pale yellow, of a granular texture, a fragrant smell, and a sweet slightly pungent taste; the latter is darker colored, thicker, and not so agreeable either in taste or smell. Honey would seem to be merely collected by the bees, for it consists of merely the vegetable products; such as the sugars of grape, gum, and manna; along with mucilage, extractive matter, a little wax, and acid.

HONEY-STONE (*Mellite*, Fr.; *Honigstein*, Germ.) is a mineral of a yellowish or reddish color, and a resinous aspect, crystallizing in octahedrons with a square base; specific gravity 1·58. It is harder than gypsum, but not so hard as calc-spar; it is deeply scratched by a steel point; very brittle; affords water by calcination; blackens, then burns at the flame of the blowpipe, and leaves a white residuum which becomes blue, when it is calcined after having been moistened with a drop of nitrate of cobalt. It is a mellate of alumina, and consists of:

	Klaproth.	Wohler.
Mellitic acid - - -	46	44·4
Alumina - - -	16	14·5
Water - - -	38	41·1
	100	100·0

The honey-stone, like amber, belongs to the geological formation of lignites. It has been hitherto found clearly in only one locality, at Artern in Thuringia.

HOP (*Houblon*, Fr.; *Hopfen*, Germ.) is the name of a well-known plant of the natural family of Urticeæ, and of the dioecia pentandria of Linnæus. The female flowers, placed upon different plants from the male, grow in ovoid cones formed of oval leafy scales, concave, imbricated, containing each at the base an ovary furnished with two tubular open styles, and sharp pointed stigmata. The fruit of the hop is a small rounded seed, slightly compressed, brownish colored, enveloped in a scaly calyx, thin but solid, which contains, spread at its base, a granular yellow substance, appearing to the eye like a fine dust, but in the microscope seen to be round, yellow, transparent grains; deeper colored, the older the fruit. This secretion, which constitutes the useful portion of the hop, has been examined in succession by Ives, Planche, Payen, and Chevalier. I have given a pretty full account of the results of their researches in treating of the hop, under the article BEER.

HORDEINE is the name given by Proust to the peculiar starchy matter of barley. It seems to be a mixture of the starch, lignine, and husks, which constitutes barley meal. See BEER.

HORN (Eng. and Germ.; *Corne*, Fr.), particularly of oxen, cows, goats, and sheep, is a substance soft, tough, semi-transparent, and susceptible of being cut and pressed into a variety of forms; it is this property that distinguishes it from bone. Turtle or tortoise shell seems to be of a nature similar to horn, but instead of being of a uniform color, it is variegated with spots.

These valuable properties render horn susceptible of being employed in a variety of works fit for the turner, snuff-box, and comb maker. The means of softening the horn need not be described, as it is well known to be by heat; but those of cutting, polishing, and soldering it, so as to make the plates of large dimensions, suitable to form a variety of articles, may be detailed. The kind of horn to be preferred is that of goats and sheep, from its being whiter and more transparent than the horn of any other animals. When horn is wanted in sheets or plates, it must be steeped in water, in order to separate the pith from the kernel, for about fifteen days in summer, and a month in winter; and after it is soaked, it must be taken out by one end, well shaken and rubbed, in order to get off the pith; after which it must be put for half an hour into boiling water, then taken out, and the surface sawed even, lengthways; it must again be put into the boiling water to soften it, so as to render it capable of separating; then, with the help of a small iron chisel, it can be divided into sheets or leaves. The thick pieces will form three leaves, those which are thin will form only two, whilst young horn, which is only one quarter of an inch thick, will form only one. These plates or leaves must again be put into boiling water, and when they are sufficiently soft, they must be scraped with a sharp cutting instrument, to render those parts that are thick even and uniform; they must be put once more into the boiling water, and finally carried to the press.

At the bottom of the press employed, there must be a strong block, in which is formed a cavity, of nine inches square and of a proportionate depth; the sheets of horn are to be laid within this cavity, in the following manner at the bottom: first a sheet of hot iron, upon this a sheet of horn, next again a sheet of hot iron, and so on, taking care to place at the top a plate of iron even with the last. The press must then be screwed down tight.

There is a more expeditious process, at least in part, for reducing the horn into sheets, when it is wanted very even. After having sawed it with a very fine and sharp saw, the pieces must be put into a copper made on purpose, and there boiled, until sufficiently soft, so as to be able to split with pincers; the sheets of horn must then be put in the press, where they are to be placed in a strong vice, the chaps of which are of iron and larger than the sheets of horn, and the vice must be screwed as quick and tight as possible; let them cool in the press or vice, or it is as well to plunge the whole into cold water. The last mode is preferable, because the horn does not shrink in cooling. Now draw out the leaves of horn, and introduce other horn to undergo the same process. The horn so enlarged in pressing, is to be submitted to the action of the saw, which ought to be set in an iron frame, if the horn is wanted to be cut with advantage, in sheets of any desired thickness, which cannot be done without adopting this mode. The thin sheets thus produced must be kept constantly very warm between plates of hot iron to preserve their softness; every leaf being loaded with a weight heavy enough to prevent its warping. To join the edges of these pieces of horn together, it is necessary to provide strong iron moulds suited to the shape of the article wanted, and to place the pieces in contact with copper-plates or with polished metal surfaces against them; when this is done, the whole is to be put into a vice and screwed up tight, then plunged into boiling water, and after some time it is to be removed from thence and immersed in cold water. The edges of the horn will be thus made to cement together and become perfectly united.

To complete the polish of the horn, the surface must be rubbed with the subnitrate of bismuth by the palm of the hand. The process is short, and has this advantage, that it makes the horn dry promptly.

When it is wished to spot the horn in imitation of tortoise-shell, metallic solutions must be employed as follows:—To spot it red, a solution of gold, in aqua regia, must be employed; to spot it black, a solution of silver in nitric acid must be used; and for brown, a hot solution of mercury in nitric acid. The right side of the horn must be impregnated with these solutions, and they will assume the colors intended. The brown spots can be produced on the horn by means of a paste made of red lead, with a solution of potash, which must be put in patches on the horn, and subjected some time to the action of heat. The deepness of the brown shades depends upon the quantity of potash used in the paste, and the length of time the mixture lies on the horn. A decoction of Brazil wood, or a solution of indigo, in sulphuric acid, or a decoction of saffron,

y wood may also be used. After having employed these materials, the horn
for half a day in a strong solution of vinegar and alum.

e, Holland, and Austria, the comb-makers and horn-turners use the clippings
ich are of a whitish yellow, and tortoise-shell skins, out of which they make
, powder-horns, and many curious and handsome things. They first soften the
ell in boiling water, so as to be able to submit them to the press in iron
d by means of heat form them into one mass. The degree of heat necessary
horn-clippings must be stronger than that for shell skins, and it can only be
by experience. The heat must not however be too great, for fear of scorching
shell. Considerable care is required in these operations, not to touch the
the fingers, nor with any greasy body, because the grease will prevent the per-
. Wooden instruments should be used to move them while they are at the
e carrying them to the moulds.

ng a ring of horn for bell-pulls, &c., the required piece is to be first cut out
of its proper dimensions, and nearly in the shape of a horse-shoe; it is then
a pair of dies to give its surface the desired pattern; but previous to the pres-
the piece of horn and the dies are to be heated; the piece of horn is to be in-
tween the dies, squeezed in a vice, and when cold, the impression or pattern
d upon the horn. One particular condition, however, is to be observed in the
on of the dies for forming a ring. They are to be so made, that the open
horse-shoe piece of horn, after being pressed, shall have at one end a nib,
other a recess of a dovetailed form, corresponding to each other; and the
ration in forming this ring of horn is to heat it, and place it in another pair
hich shall bring its open ends together, and cause the dovetailed joints to be
t into each other, which completes the ring, and leaves no appearance of the

ng the handles of table knives and forks, or other things which require to be
wo pieces, each of the two pieces or sides of the handle is formed in a separate
e; the one piece is made with a counter-sunk groove along each side, and the
with corresponding leaves or projecting edges. When these two pieces are
first being cut out of the flat horn, then pressed in the dies in a heated state,
rpose of giving the pattern, the two pieces are again heated and put together,
or edges of the one piece dropping into the counter-sunk grooves of the other
being introduced between another pair of heated dies, the joints are pressed
nd the two pieces formed into one handle.

ng the knobs for drawers which have metal stems or pins to fasten them into
or, the face of the knob is to be first made in a die, as above described, and
ack part of the knob with a hole in it; a metal-disc of plate-iron is next pro-
which the metal stem or screw pin is fixed, and the stem being passed through
re in the back piece, and the two, that is, the back and front pieces of horn
rt, they are then heated and pressed in dies as above described; the edge of
rce falling into the counter-sunk groove of the front piece, while by the heat
fectly cemented together.

ILVER (*Argent Corné*, or *Kerargyre*, Fr.; *Hornsilber*, Germ.) is a white or
mineral, sectile like wax or horn, and crystallizing in the cubic system.
gravity varies from 4·75 to 5·55. Insoluble in water; not volatile; fusible
pipe, but difficult of reduction by it. It deposites metallic silver when rubbed
t upon a piece of clean copper or iron. It consists of 24·67 chlorine, and 75·32

er is rare in the European mines, but it occurs in great quantity in the districts
us, Fresnillo, and Catarce, in Mexico; and in Huantajaya, Yauricocha, &c.,
where it is abundantly mixed with the ores of hydrate of iron, called Pacos
alos, interspersed with wires of metallic silver, which form considerable depos-
procian limestones. T   profitably mined as an ore of silver.
STONE is a variety of   al quartz. Being both hard and tough, it is
ed to form the stones   lls for grinding flints; it is called chert in
r, where it abounds
ne occurs under the   splintery hornstone, conchoidal horn-
wood-tone. The   two are gray, white, and red; they are
e; dull, or of a g   translucent only on the thin edges. Diffi-
ah. Hornstone is   and by its infusibility before the blow-
r be distinguished   it resembles in external appearance.
gical locality of   ; for it occur   both ancient and
ations. It is found   ns that   rimitive crystalline
ng up the intersticrs   metallic   the lead mine of
in Brittany it is whi   dur   curs likewise in
beds of the coarse lime   ner)   ain, which is a

comparatively modern formation, as well as in the sand beds of the upper parts of the district, near Saint Cloud, Neuilly, &c. The hornstone which occurs in secondary lime-stone is called *chert* by the English miners. It is valuable for forming the grinding blocks of flint mills in the pottery manufacture.

HORSE POWER, in steam engines, is estimated by Mr. Watt at 32,000 pounds avoirdupois lifted one foot high per minute, for one horse. M. D'Aubuisson, from an examination of the work done by horses in the whims, or gigs (*machines à molettes*) for raising ore from the mines at Freyberg, the horses being of average size and strength, has concluded that the useful effect of a horse yoked during eight hours, by two relays of four hours each, in a manege or mill course, may be estimated at 40 kilogrammes raised 1 mètre per second; which is nearly 16,440 pounds raised one foot per minute; being very nearly one half of Mr. Watt's liberal estimate for the work of his steam engines.

HOSIERY (*Bonnèterie*, Fr.; *Strumpfweberei*, Germ.). The *stocking frame*, which is the great implement of this business, though it appears at first sight to be a complicated machine, consists merely of a repetition of parts easily understood, with a moderate degree of attention, provided an accurate conception is first formed of the nature of the hosiery fabric. This texture is totally different from the rectangular decussation which constitutes cloth, as the slightest inspection of a stocking will show; for this, instead of having two distinct systems of thread, like the warp and the weft, which are woven together, by crossing each other at right angles, the whole piece is composed of a single thread united or looped together in a peculiar manner, which is called stocking-stitch, and sometimes chain-work.

This is best explained by the view in *fig.* 550. A single thread is formed into a number of loops or waves, by arranging it over a number of parallel needles, as shown at R : these are retained or kept in the form of loops or waves, by being drawn or looped through similar loops or waves formed by the thread of the preceding course of the work, s. The fabric thus formed by the union of a number of loops is easily unravelled, because the stability of the whole piece depends upon the ultimate fastening of the first end of the thread; and if this is undone, the loops formed by that end will open, and release the subsequent loops,
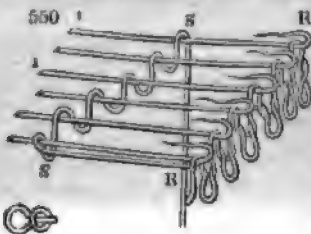
one at a time, until the whole is unravelled, and drawn out into the single thread from which it was made. In the same manner, if a thread in a stocking-piece fails, or breaks at any part, or drops a stitch, as it is called, it immediately produces a hole, and the extension of the rest can only be prevented by fastening the end. It should be observed that there are many different fabrics of stocking-stitch for various kinds of ornamental hosiery, and as each requires a different kind of frame or machine to produce it, we should greatly exceed our limits to enter into a detailed description of them all. That species which we have represented in *fig.* 550 is the common stocking-stitch used for plain hosiery, and is formed by the machine called the common stocking-frame, which is the groundwork of all the others. The operation, as we see, consists in drawing the loop of a thread successively through a series of other loops, so long as the work is continued, as is very plainly shown for one stitch in *fig.* 551.

There is a great variety of different frames in use for producing various ornamental kinds of hosiery. The first, which forms the foundation of the whole, is that for knitting plain hosiery, or the common stocking-frame.

Of this valuable machine, the invention of Mr. Lee, of Cambridge, a side elevation is given in *fig.* 552, with the essential parts. The framing is supported by four upright posts, generally of oak, ash, or other hard wood. Two of these posts appear at A A, and the connecting cross rails are at C C. At B is a small additional piece of framing, which supports the hosier's seat. The iron-work of the machine is bolted or screwed to the upper rails of the frame-work, and consists of two parts. The first rests upon a sole of polished iron, which appears at D, and to which a great part of the machinery is attached. The other part, which is generally called the carriage, runs upon the iron sole at D, and is supported by four small wheels, or trucks, as they are called by the workmen. At the upper part of the back standard of iron are joints, one of which appears at Q; and to these is fitted a frame, one side of which is seen extending to H. By means of these joints, the end at H may be depressed by the hosier's hand, and it returns, when relieved, by the operation of a strong spring of tempered steel, acting between a cross bar in the frame and another below. The action of this spring is very apparent in *fig.* 553. In the front of the frame, immediately opposite to where the hosier sits, are placed the needles which form the loops. These needles, or rather

hooks, are more or less numerous, according to the coarseness or fineness of the stocking; and this, although unavoidable, proves a very considerable abatement of the value of a stocking-frame. In

almost every other machine (for example, those employed in spinning or weaving), it is easy to adapt any one either to work coarser or finer work, as it may be wanted. But in the manufacture of hosiery, a frame once finished, is limited for ever in its operation to the same quality of work, with this exception, that by changing the stuff, the work may be made a little more dense or flimsy; but no alteration in the size or quantity of loops can take place. Hence where the manufacture is extensively prosecuted, many frames may be thrown idle by every vicissitude of demand; and where a poor mechanic does purchase his own frame, he is for ever limited to the same kind of work. The gauge, as it is called, of a stocking-frame is regulated by the number of loops contained in three inches of breadth, and varies very much; the coarsest frames in common use being about what are termed Fourteens, and the finest employed in great extent about Forties. The needles are of iron wire, the manufacture of which is very simple; but long practice in the art is found necessary before a needle-maker acquires the dexterity, which will enable him both to execute his work well, and in sufficient quantity to render his labor productive.
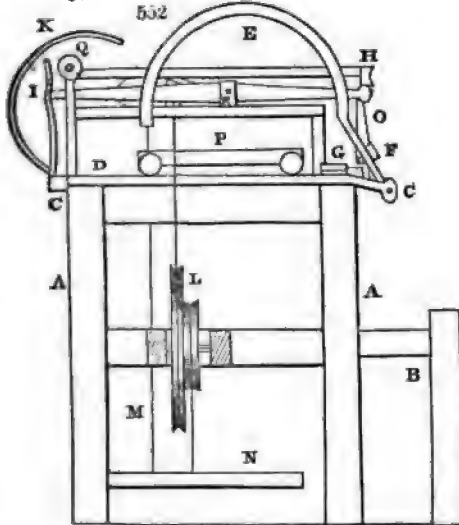
The process of making the needles is as follows:—Good sound iron wire, of a proper fineness, is to be selected; that which is liable to split or splinter, either in filing, punching, or bending, being totally unfit for the purpose. The wire is first to be cut into proper lengths, according to the fineness of the frame for which the needles are designed, coarse needles being considerably longer than fine ones. When a sufficient number (generally some thousands) have been cut, the wire must be softened as much as possible. This is done by laying them in rows in a flat iron box, about an inch deep, with a close cover; the box being filled with charcoal between the strata of wires. This box, being placed upon a moderate fire, is gradually heated until both the wires and charcoal have received a moderate red heat, because, were the heat increased to what smiths term the white heat, the wire would be rendered totally unfit for the subsequent processes which it has to undergo, both in finishing and working. When the box has been sufficiently heated, it may be taken from the fire, and placed among hot ashes, until both ashes and box have gradually cooled; for the slower the wires cool, the softer and easier wrought they will be. When perfectly cool, the next process is to punch a longitudinal groove in the stem of every needle, which receives the point or barb, when depressed. This is done by means of a small engine worked by the power of a screw and lever. The construction of these engines is various; but a profile
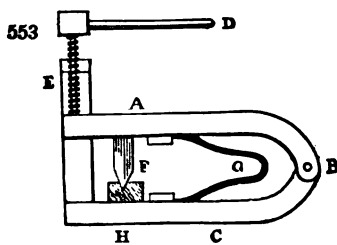
elevation of one of the most simple and commonly used will be found in *fig.* 553. It consists of two very strong pieces of malleable iron, represented at A and c, and these two pieces are connected by a strong well-fitted joint at B. The lower piece, or sole of the engine at c, is screwed down by bolts to a strong board or table, and the upper piece A will then rise or sink at pleasure, upon the joint B. In order that A may be very steady in rising and sinking, which is indispensable to its correct operation, a strong bridle of iron, which is shown in section at E, is added to confine it, and direct its motion. In the upper part of this bridle is a female screw, through which the forcing screw passes, which is turned by the handle or lever D. To the sole of the engine c is fixed a bolster

of tempered steel, with a small groove to receive the wire, which is to be punched; and in the upper or moving part A, is a sharp chisel, which descends exactly into the groove, when A is depressed by the screw. These are represented at F, and above H. At G is a strong spring, which forces up the chisel when the pressure of the screw is removed. The appearance of the groove, when the punching is finished, will be rendered familiar by inspecting *fig*. 554, p. 657. When the punching is finished, the wires are to be brought to a fine smooth point by filing and burnishing, the latter of which should be very completely done, as, besides polishing the wire, it tends greatly to restore that spring and elasticity which had been removed by the previous operation of softening. The wire is next to be bent, in order to form the hook or barb; and this is done with a small piece of tin plate bent double, which receives the point of the wire, and by its breadth regulates the length of the barb. The stem of the needle is now flattened with a small hammer, to prevent it from turning in the tin socket in which it is afterwards to be cast; and the point of the barb being a little curved by a pair of small pliers, the needle is completed.

In order to fit the needles for the frame, they are now cast into the tin sockets, or leads, as they are called by the workmen; and this is done by placing the needles in an iron mould, which opens and shuts by means of a joint, and pouring in the tin while in a state of fusion. In common operations, two needles are cast into the same socket. The form of the needle, when complete and fitted to its place in the frame, will be seen in *fig*. 555, which is a profile section of the needle-bar, exhibiting one needle. In this figure a section of the pressure is represented at F; the needle appears at G, and the socket or level at K. At H, is a section of the needle-bar, on the fore part of which is a small plate of iron called a verge, to regulate the position of the needles. When placed upon the bar resting against the verge, another plate of iron, generally lined with soft leather, is screwed down upon the sockets or leads, in order to keep them all fast. This plate and the screw appear at I. When the presser at F is forced down upon the barb, this sinks into the groove of the stem, and the needle is shut; when the presser rises, the barb opens again by its own elasticity.
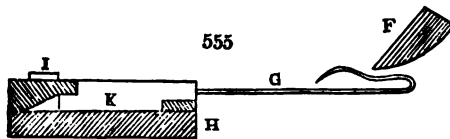
The needles or hooks being all properly fitted, the next part of the stocking-frame to which attention ought to be paid, is the machinery for forming the loops; and this consists of two parts. The first of these, which sinks between every second or alternate needle, is represented at o, *fig*. 552, and is one of the most important parts of the whole machine. It consists of two moving parts; the first being a succession of horizontal levers moving upon a common centre, and called jacks, a term applied to vibrating levers in various kinds of machinery as well as the stocking-frame. One only of these jacks can be represented in the profile *fig*. 552; but the whole are distinctly shown in a horizontal position in *fig*. 556; and a profile upon a very enlarged scale is given in *fig*. 557.
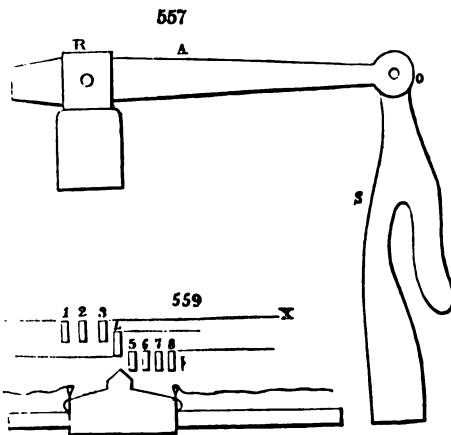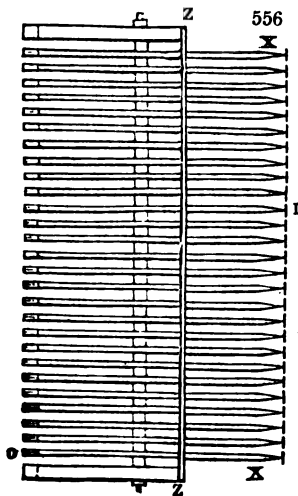
he jack shown in *fig.* 552, extends horizontally from o to ɪ, and the centre of motion at ʀ. On the front, or right hand part of the jack at o, is a joint suspending a very in plate of polished iron, which is termed a sinker. One of these jacks and sinkers is lotted for every second or alternate needle. The form of the sinker will appear at s, g. 557; and in order that all may be exactly uniform in shape, they are cut out and ushed between two stout pieces of iron, which serve as moulds or gauges to direct the ame-smith. The other end of the jack at ɪ, is tapered to a point; and when the jacks e in their horizontal position, they are secured by small iron springs, one of which is presented at ɪ, *fig.* 552, each spring having a small obtuse angled notch to receive the int of the jack, against which it presses by its own elasticity. In *fig.* 557 the centre is ʀ; the pointed tail is omitted for want of room, the joint is at o, and the throat of the aker, which forms the loop, is at s. The standards at ʀ, upon which the jack moves, e called combs, and consist of pieces of flat smooth brass, parallel to, and equidistant om each other. The cross-bar ʀ, which contains the whole, is of iron, with a perpen- cular edge or rim on each side, leaving a vacancy between them, or a space to receive e bottom part or tails of the combs. The combs are then placed in the bar, with a flat ece of brass called a countercomb, between each, to ascertain and preserve their distances om each other. These countercombs are exactly of the same shape as the combs, but ve no tails. When both combs and countercombs are placed in the bar, it is luted ith clay so as to form a mould, into which is poured a sufficient quantity of melted tin. hen the tin has had time to cool, the countercombs having no tails are easily taken out, d the combs remain well fastened and secured by the tin, which has been fused entirely und them. Thus they form a succession of standards for the jacks; and a hole being lled through each jack and each comb, one polished wire put through, serves as a com- on centre for the whole.

The jack sinkers being only used for every alternate or second needle, in order to mplete this part of the apparatus, a second set of sinkers is employed. These are, in m and shape, every way the same as the jack sinkers, but they are jointed at the top o pieces of tin, all of which are screwed to the sinker bar ʜ, *fig.* 552; and thus a aker of each kind descends between the needles alternately. By these sinkers the ops are formed upon all the needles, and the reason of two sets different in operation ing employed, will be assigned in describing the mode of working the frame. The esser of the operation, of which something has already been said, appears at ꜰ; and the two arms which support and give motion to it, one appears very plainly at ᴇ, its atre of motion being at c. The circular bend given to these arms, besides having an ornamental effect, is very useful, in order to prevent any part from interfering with the other parts which are behind, by elevating them entirely above them. The extremities of these arms at the termination of the bends behind, are connected by a cross bar, which has also a circular bend in the middle, projecting down- wards, for a reason similar to that already assigned. This bend is concealed in *fig.* 552, but visible in the front elevation, *fig.* 558. From the middle of the bend, the presser is connected with the middle treadle by a depending wire appearing at ᴍ, *fig.* 552, and thus, by the pressure of that treadle, the presser is forced down to close the barbs of the needle. The re-ascent of the presser is sometimes effected by means of a counterpoising weight passing over a pulley behind; and some- times by the reaction of a wooden spring, formed of a strong hoop like that represented at ᴋ. The latter of these is preferred, espe- cially by the Nottingham hosiers, because, as they assert, it makes the presser spring up with greater
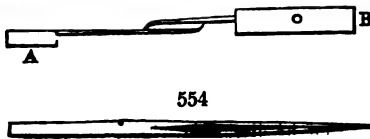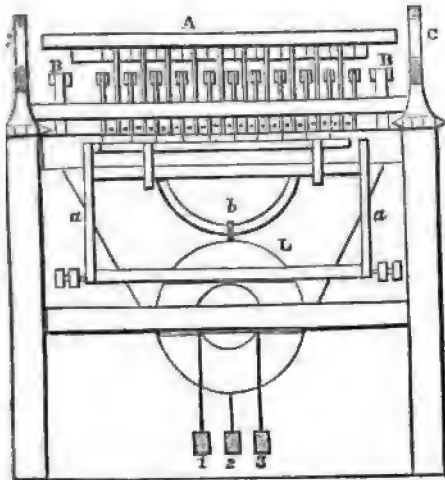
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rapidity, and consequently saves time in working. How far this may be practically the case, it would be superfluous here to investigate; but it is obvious that the wooden spring, if very stiff, must add much to the hosier's exertion of his foot, already exercised against the united spring of all his barbs; and this inconvenience is much complained of by those who have been accustomed to work with the counterpoise.

At L are two pulleys or wheels, of different diameters, moving upon a common centre, by which the jack sinkers are relieved from the back springs, and thrown downwards to form the loops upon the needles. About the larger wheel is a band of whipcord, passing twice round, the extremities of which are attached to what is called the slur, which disengages the jacks from the back springs. The smaller pulley, by another band, communicates with the right and left treadle; so that these treadles, when pressed alternately, turn the pulleys about in an inverted order. The directions of these bands also appear more plainly in the front elevation, *fig.* 558. The construction of the slur, and its effect upon the jacks, will also be rendered apparent by *fig.* 559. In this figure, eight jacks are represented in section, the tail part of three of which, 1, 2, 3, are thrown up by the slur in its progress from left to right; the fourth is in the act of rising, and the remaining four, 5, 6, 7, and 8, are still unacted upon, the slur not yet having reached them. As the slur acts in the direction of the dotted line x, x, *fig.* 556, behind the centres of the jacks, it is hardly necessary to remark, that this forcing up of the tails must of course depress the joints by which the sinkers in front are suspended. The jack sinkers falling successively from the loops on every alternate needle, in the way

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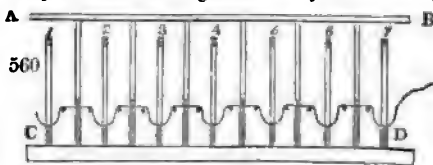
represented at *fig.* 560, where both kinds of sinkers appear in section, the light part expressing what is above the point at which the throat of the sinker operates upon the thread, and the dark part what is below. The second set, or, as they are called, the lead sinkers, from the manner of jointing them, and suspending them from the bar above, appear still elevated; the position of the bar being represented by the line A, B. But when these are pulled down to the level of the former by the operator's hands, the whole looping will be completed, and the thread c, D, which is still slack, will be brought to its full and proper degree of tension, which is regulated by stop screws, so as to be tempered or altered at pleasure.

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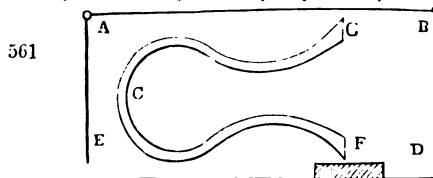
The sinking of this second set of sinkers, may be easily explained by *fig.* 561. The direction of the sinkers is expressed by the line E; the bar from which they are suspended will be at A; the top frame is in the direction from A to B; the back standards at D, and the joint at R, is the centre of motion. If E is pulled perpendicularly downwards, the spring c will be contracted, and its upper extreme point G, will be brought nearer to its lower extreme point F, which is fixed. Again, when the force which has depressed E is removed, the spring c will revert to its former state, and the sinkers will rise. The raising of the jack sinkers and jacks takes place at the same time, by the hosier raising his hands; and for the cause of this we must revert to *fig.* 556. The lead sinkers in rising lay hold of notches, which raise the extreme parts of the set of jacks z, z, which are called half-jacks. Between the extremities of these at z, z, is a cross bar, which, in descending, presses all the intermediate jacks behind the common centre, and restores them to their original posture, where they are secured by the back springs, until they are again relieved by the operation of the slur recrossing at the next course.

Working of the frame.—In order to work a frame, the whole apparatus being previously put into complete order, the hosier places himself on the seat B in front, and provides himself with a bobbin of yarn or stuff. This bobbin he places loosely on a vertical pin of wire, driven into one side of the frame contiguous to the needles, so that it may turn freely as the stuff is unwound from it. Taking the thread in his hand, he draws it loosely along the needles, behind the barbs, and under the throats of the sinkers. He then presses down one of the treadles to pass the slur along, and unlock the jacks from the back springs, that they may fall in succession. When this is done, the number of loops thus formed is doubled by bringing down the lead sinkers, and the new formed loops are lodged under the barbs of the needles by bringing forward the sinkers. The preceding course, and former fabric, being then again pushed back, the barbs are shut by depressing the middle treadle, and forcing down the presser upon the needles. The former work is now easily brought over the shut needles, after which, by raising the

hands, both sets of sinkers are raised; the jacks are locked by the back springs, and the hosier goes on to another course.

From this it will be apparent, that the remark made in the outset is well founded, that there are, in reality, no complicated or difficult movements in the stocking-frame. Almost the whole are merely those of levers moving upon their respective fulcra, excepting that of the carriage which gives the horizontal motion to the sinkers, and that is merely an alternate motion on four wheels. Yet the frame is a machine which requires considerable experience and care, both to work it to advantage, and also to keep it in good order. This circumstance arises greatly from the small compass in which a number of moving parts must be included. Owing to this, the needles, unless cautiously and delicately handled, are easily bent or injured. The same circumstance applies with equal or greater force to the sinkers, which must be so very thin as to be easily injured. But as these must work freely, both in a perpendicular and horizontal direction between the needles, in a very confined and limited space, the slightest variation in either, from being truly and squarely placed, unavoidably injures the others. When a hosier, either ignorant of the mechanical laws, of their relation to each other, or too impatient to wait for the assistance of another, attempts to rectify defects, he in most cases increases them tenfold, and renders the machine incapable of working at all, until repaired by some more experienced person. This circumstance has given rise to a set of men employed in this trade, and distinguished by the name of upsetters; and these people, besides setting new frames to work, have frequently more employment in repairing old ones injured by want of care or skill, than many country apothecaries, who live in unhealthy parishes, find in tampering with the disorders of mankind.

It seems unnecessary to go further into detail respecting a machine so well known, and which requires practical attention even more than most others. It may, therefore, be sufficient to describe shortly some of its varieties, the most simple and common of which is the rib stocking-frame.

Rib stocking-frame. — This frame, which, next to the common frame, is most extensively in use, is employed for working those striped or ribbed stockings, which are very common in all the different materials of which hosiery is formed. In principle it does not differ from the common frame, and not greatly in construction. The preceding general description will nearly apply to this machine with equal propriety as to the former; that part, however, by which the ribs or stripes are formed, is entirely an addition, and to the application of this additional machinery it may be proper to pay the chief attention, referring chiefly to *fig.* 558, which is a front elevation.

This figure has been already referred to for the illustration of those parts of the machinery which are common to both, and those parts therefore require no recapitulation. The principle of weaving ribbed hosiery possesses considerable affinity to that which subsists in the weaving of that kind of cloth which is distinguished by the name of tweeling, for the formation of stripes, with some variation arising merely from the different nature of the fabric. In cloth weaving, two different kinds of yarn intersecting each other at right angles, are employed; in hosiery only one is used. In the tweeling of cloth, striped as dimity, in the cotton or kerseymere, and in the woollen manufacture, the stripes are produced by reversing these yarns. In hosiery, where only one kind of yarn is used, a similar effect is produced by reversing the loops. To effect this reversing of the loops, a second set of needles is placed upon a vertical frame, so that the bends of the hooks may be nearly under those of the common needles. These

needles are cast into tin moulds, pretty similar to the former, but more oblique or bevelled towards the point, so as to prevent obstructions in working them. They are also screwed to a bar of iron, generally lighter than the other, and secured by means of plates : this bar is not fixed, but has a pivot in each end, by means of which the bar may have a kind of oscillatory motion on these pivots. The two frames of iron support this bar; that in which it oscillates being nearly vertical, but inclined a little towards the other needles. *Fig.* 562, which is a profile elevation, will serve to illustrate the relative position of each bar to the other. The lower or horizontal frame, the ends only of which can be seen in *fig.* 558 under *a a*, appears in profile in *fig.* 562, where it is distinguished by *d*. The vertical frame at *a* is attached to this by two centre screws, which serve as joints for it to move in. On the top of this frame is the rib-needle bar at *f*, in *figs.* 552 and 562, and one needle is represented in *fig.* 562 at *f*. At *g* is a small presser, to shut the barbs of the rib-needles, in the same manner as the large one does those of the frame. At *h* is one of the frame needles, to show the relative position of the one set to the other. The whole of the rib-bar is not fitted with needles like the other; for here needles are only placed where ribs or stripes are to be formed, the intervals being filled up with blank leads, that is
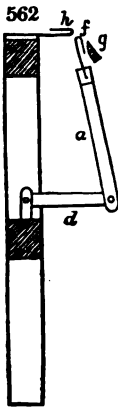
to say, with sockets of the same shape as the others, but without needles; being merely designed to fill the bar and preserve the intervals. Two small handles depend from the needle bar, by which the oscillatory motion upon the upper centres is given. The rising and sinking motion is communicated to this machine by chains which are attached to iron sliders below, and which are wrought by the hosier's heel when necessary. The pressure takes place partly by the action of the small presser, and partly by the motion of the needles in descending. A small iron slider is placed behind the rib-needles, which rises as they descend, and serves to free the loops perfectly from each other.

In the weaving of ribbed hosiery, the plain and rib courses are wrought alternately. When the plain are finished, the rib-needles are raised between the others, but no additional stuff is supplied. The rib-needles, intersecting the plain ones, merely lay hold of the last thread, and, by again bringing it through that which was on the rib-needle before, give it an additional looping, which reverses the line of chaining, and raises the rib above the plain intervals, which have only received a single knitting.

HOT-FLUE is the name given in England to an apartment heated by stoves or steam pipes, in which padded and printed calicoes are dried hard. *Fig.* 563 represents

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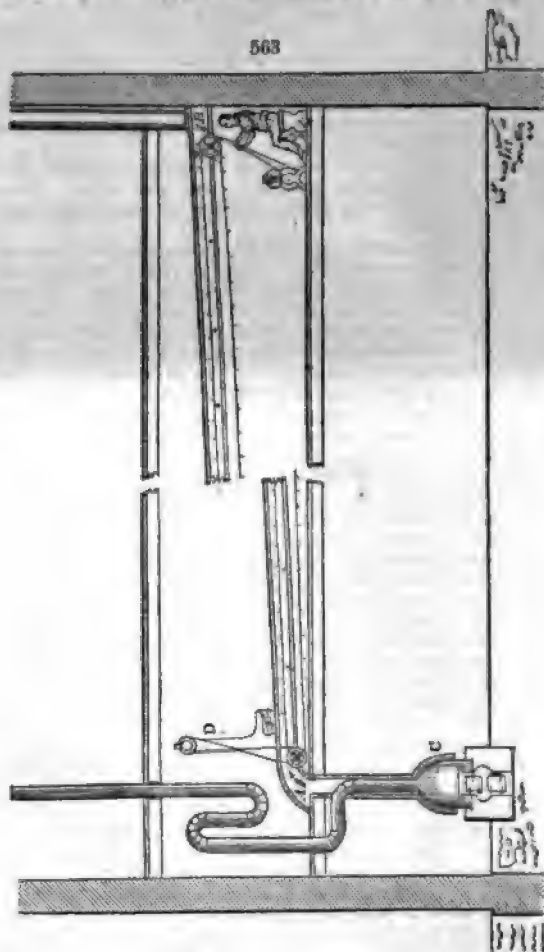
the simplest form of such a flue, heated by the vertical round iron stove c, from whose top a wide square pipe proceeds upwards in a slightly inclined direction, which receives the current of air heated by the body and capital of the stove. In this wide channel there are pulleys, with cords or bands which suspend by hooks, and conduct the web of

calico, from the entrance at B, where the operative sits, to near the point A, and back again. This circuit may be repeated once or oftener till the goods are perfectly dried. At D the driving pulley connected with the main shaft is shown. Near the feet of the operative is the *candroy* or reel upon which the moist goods are rolled in an endless web; so that their circulation in the hot-air channel can be continued without interruption, as long as may be necessary.

Fig. 564 is a cross section of the apparatus of the regular hot-flue, as it is mounted

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in the most scientific calico works of England, those of James Thomson, Esq., of Primrose, near Clitheroe, Lancashire. *a a a a*, is an arched apartment, nearly 30 yards long, by 13 feet high, and 10 feet wide. Through about one half of this gallery there is a horizontal floor supported on arches, above which is the driest space, through which the goods are finally passed before they escape from the hot-flue, after they have been previously exposed to the hot but somewhat moist air of the lower compartment. A large square flue covered with cast-iron plates runs along the whole bottom of the gallery. It is divided into two long parallel vaults, whose sections are seen at *u, u, fig.* 564, covered with the cast-iron plates *v v*, grooved at their ends into one another. The thickness of these plates is increased progressively as they come nearer to the fireplace or furnace. There are dampers which regulate the draught, and of course the heat of the stove. *h h* are the air-passages or vent-holes, left in the side walls, and which by means of a long iron rod, mounted with iron plates, may be opened or closed together to any degree. *k k* are the cast-iron supports of the tinned brass rollers which guide the goods along, and which are fixed to the cross pieces represented by *r r, fig.* 564. *l l* are iron bars for supporting the ventilators or fans (see the fan under Foundry). These fans are here enclosed within a wire grating. They make about 300 turns per minute, and expel the moist air with perfect effect. *s* indicates the position of the windows, which extend throughout the length of the building. *t* is a gas-light jet, placed at the side of each window to supply illumination for night work.

The piece is stretched along the whole extent of the gallery, and runs through it in the course of one minute and a half; being exposed during its passage to the heat of 212° Fahr.

In *fig.* 565, A is the iron door of entrance to the hot-flue gallery; at *b* is the padding machine, where the goods are imbued with the general mordant. The speed of

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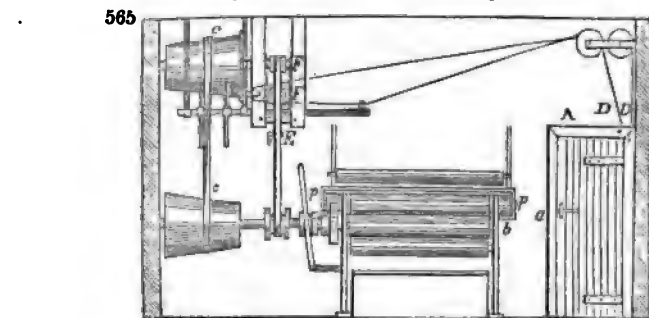
this machine may be varied by means of the two conical drums *c c*, which drive it; since when the band *c c* is brought, by its forks and adjusting screws, nearer to the narrow end of the lower drum, the cylinder upon the same shaft with the latter is driven quicker; and *vice versa*. Over D D the cords are shown for drawing the drum mechanism into gear with the main shaft band, F F E; or for throwing it out of gear. The pulleys F F carry the bands which transmit the motion to the padding machine. A cylindrical drum exterior to the hot-flue, covered with flannel, serves to receive the end of the series of pieces, and to draw them through the apartment. This mode of drying

the padded calicoes requires for each piece of 28 yards, 3 pounds of coals for the furnace when a fan is employed, and 4 pounds without it.

HYDRATES are compounds of the oxydes, salts, &c. with water in definite or equivalent proportions. Thus slaked lime consists of one atom of quick-lime = 28, + one atom of water = 9. of which the sum is 37 on the hydrogen scale.

HYDRAULIC PRESS. See OIL, PRESS, and STEARINE.

HYDRIODIC ACID (*Acide Hydriodique*, Fr.; *Hydriodsäure*, Germ.) is an acid formed by the combination of 99·21 parts of iodine, and 0·79 hydrogen. When pure, it occurs in the gaseous state, but it combines with water like the hydrochloric or muriatic acid gas into a liquid acid. ·

HYDROCHLORIC ACID; the new chemical name of muriatic acid, which see.

HYDROGEN (Eng. and Fr.; *Wasserstoff*, Germ.), an undecompounded gaseous body; the lightest of all ponderable matter, whose examination belongs to chemistry.

HYDROMETER; an instrument for ascertaining the specific gravities of liquids. Baumé's hydrometer, which is much used in France, and other countries of the continent of Europe, when plunged in pure water, at the temperature of 58° Fahr., marks 0 upon its scale; in a solution containing 15 per cent. of common salt (chloride of sodium) and 85 of water by weight, it marks 15°; so that each degree is meant to indicate a density corresponding to one per cent. of that salt. See AREOMETER, for comparative tables of hydrometers.

HYDROSULPHURETS; chemical compounds of bases with sulphureted hydrogen.

HYMENŒA COURBARIL; a tree growing in South America, from which the resin *animé* exudes.

HYOSCIAMUS NIGER. Henbane is a plant used in medicine, from which modern chemistry has extracted a new crystalline vegetable principle called *hyosciamine*, which is very poisonous, and when applied in solution to the eye, determines a remarkable dilatation of the pupil; as *belladonna* also does.

HYPOSULPHATES; HYPOSULPHITES; saline compounds of the hyposulphuric or hyposulphurous acid with bases.

HYPEROXYMURIATES; the old and incorrect name of CHLORATES.

I. & J.

JACK, called also *jack in a box*, and *hand jack*, is a portable mechanical instrument, consisting of a rack and pinion, or a pair of claws and ratchet bar, moved by a winch handle, for raising heavy weights a little way off the ground.

JACK and JACK-SINKERS, are parts of a stocking frame; see HOSIERY.

JACK-BACK, is the largest jack of the brewer.

JACQUARD. A peculiar and most ingenious mechanism, invented by M. Jacquart of Lyons, to be adapted to a silk or muslin loom for superseding the employment of draw-boys, in weaving figured goods. Independently of the ordinary play of the warp threads for the formation of the ground of such a web, all those threads which should rise simultaneously to produce the figure, have their appropriate healds, which a child formerly raised by means of cords, that grouped them together into a system, in the order, and at the time desired by the weaver. This plan evidently occasioned no little complication in the machine, when the design was richly figured; but the apparatus of Jacquart, which subjects this manœuvre to a regular mechanical operation, and derives its motion from a simple pedal put in action by the weaver's feet, was generally adopted soon after its invention in 1800. Every common loom is susceptible of receiving this beautiful appendage. It costs in France, 200 francs, or 8*l.* sterling; and a little more in this country.

Fig. 566 is a front elevation of this mechanism, supposed to be let down. *Fig.* 567 is a cross section, shown in its highest position. *Fig.* 568 the same section as the preceding, but seen in its lower position.

A, is the fixed part of the frame, supposed to form a part of the ordinary loom; there are two uprights of wood, with two cross bars uniting them at their upper ends, and leaving an interval *x y*, between them, to place and work the moveable frame B, vibrating round two fixed points *a a*, placed laterally opposite each other, in the middle of the space *x y*, *fig.* 566.

c, is a piece of iron with a peculiar curvature, seen in front, *fig.* 566, and in profile, *figs.* 567 and 568. It is fixed on one side upon the upper cross-bar of the frame B, and on the other, to the intermediate cross-bar *b* of the same frame, where it shows an inclined curvilinear space *c*, terminated below by a semi-circle.

D, is a square wooden axis, moveable upon itself round two iron pivots, fixed into its two

ends; which axis occupies the bottom of the moveable frame B. The four faces of this square axis are pierced with three round, equal, truly-bored holes, arranged in a quin-

eunx. The teeth a, *fig.* 570, are stuck into each face, and correspond to holes c, *fig.* 573, made in the cards which constitute the endless chain for the healds ; so that in the suc-cessive application of the cards to each face of the square axis, the holes pierced in one card may always fall opposite to those pierced in the other.
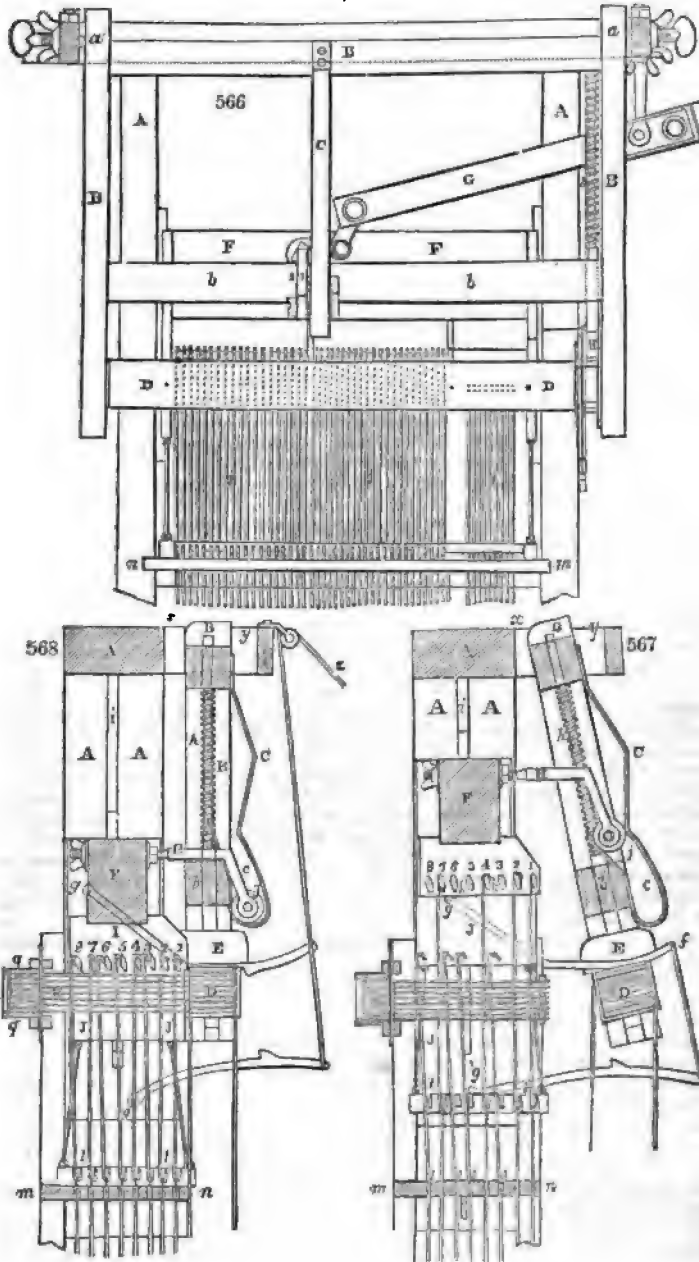
The right-hand end of the square axis, of which a section is shown in double size, *fig.* 569, carries two square plates of sheet iron *d*, kept parallel to each other and
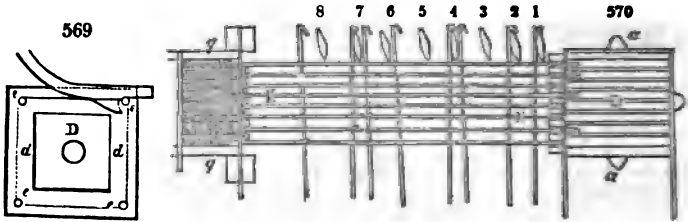
a little apart, by four spindles *e*, passed opposite to the corners.　This is a kind of lantern, in whose spindles the hooks of the levers *f f*, turning round fixed points *g g* beyond the right hand upright A, catch hold, either above or below, at the pleasure of the weaver, according as he merely pulls or lets go the cord *z*, during the vibratory movement of the frame B.

E is a piece of wood shaped like a T, the stem of which, prolonged upwards, passes freely through the cross-bar *b*, and through the upper cross-bar of the frame B, which serve as guides to it.　The head of the T piece being applied successively against the two spindles *e*, placed above in a horizontal position, first by its weight, and then by the spiral spring *h*, acting from above downwards, keeps the square axis in its position, while it permits it to turn upon itself in the two directions.　The name *press* is given to the assemblage of all the pieces which compose the moveable frame B B.

F is a cross-bar made to move in a vertical direction by means of the lever G, in the notches or grooves *i*, formed within the fixed uprights A.

H is a piece of bent iron, fixed by one of its ends with a nut and screw, upon the cross-bar F, out of the vertical plane of the piece C.　Its other end carries a friction roller J, which working in the curvilinear space *c* of the piece C, forces this, and consequently the frame B, to recede from the perpendicular, or to return to it, according as the cross-bar F is in the top or bottom of its course, as shown in *figs.* 567 and 568.

I, cheeks of sheet iron attached on either side to the cross-bar F, which serve as a safe to a kind of claw K, composed here of eight small metallic bars, seen in section *fig.* 567 and 568, and on a greater scale in *fig.* 570.

J, upright skewers of iron wire, whose tops, bent down hook-wise, naturally place themselves over the little bars K.　The bottom of these spindles, likewise hooked in the same direction as the upper ones, embraces small wooden bars *l*, whose office is to keep them in their respective places, and to prevent them from twirling round, so that the uppermost hooks may be always directed towards the small metallic bars upon which they impend.　To these hooks from below are attached strings, which, after having crossed a fixed board *m n*, pierced with corresponding holes for this purpose, proceed next to be attached to the threads of the loops destined to lift the warp threads.　K K, horizontal spindles or needles, arranged here in eight several rows, so that each spindle corresponds both horizontally and vertically to each of the holes pierced in the four faces of the square axis D.　There are therefore as many of these spindles as there are holes in one of the faces of the square.

Fig. 571 represents one of these horizontal spindles.　*n* is an eyelet through which the
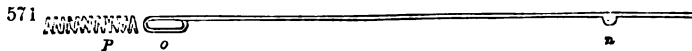
corresponding vertical skewer passes.　*o* another elongated eyelet, through which a small fixed spindle passes to serve as a guide, but which does not hinder it from moving length-wise, within the limits of the length of the eyelet.　*p*, small spiral springs placed in each hole of the case *q q*, *fig.* 570.　They serve the purpose of bringing back to its primitive position, every corresponding needle, as soon as it ceases to press upon it.

Fig. 572 represents the plan of the upper row of horizontal needles.　*Fig.* 573 is a fragment of the endless chain, formed with perforated cards, which are made to circulate
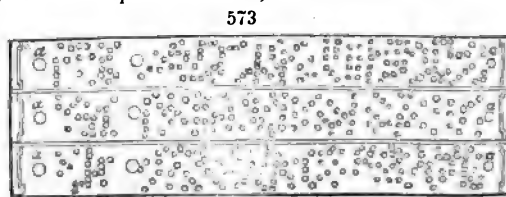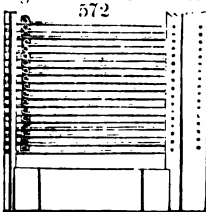
travel by the rotation of the shaft D. In this movement, each of the perforated cards, whose position, form, and number, are determined by the operation of tying-up of the warp, comes to be applied in succession against the four faces of the square axis or drum, having open the corresponding holes, and covering those upon the face of the axis, which have no corresponding holes upon the card.

Now let us suppose that the *press* B is let down into the vertical position shown in fig. 568; then the card applied against the left face of the axis, leaves at rest or untouched the whole of the horizontal spindles (skewers), whose ends correspond to these holes, but pushes back those which are opposite to the unpierced part of the card; thereby the corresponding upright skewers, 3, 5, 6, and 8, for example, pushed out of the perpendicular, unhook themselves from above the bars of the claw, and remain in their place, when this claw comes to be raised by means of the lever G; and the skewers 1, 2, 4, and , which have remained hooked on, are raised along with the warp threads attached to them. Then by the passage across of a shot of the color, as well as a shot of the common weft, and a stroke of the lay after shedding the warp and lowering the press B, an element of point in the pattern is completed.

The following card, brought round by a quarter revolution of the axis, finds all the needles in their first position, and as it is necessarily perforated differently from the preceding card, it will lift another series of warp threads; and thus in succession for all the other cards, which compose a complete system of a figured pattern.

This machine, complicated in appearance, and which requires some pains to be understood, acts however in a very simple manner. Its whole play is dependant upon the movement of the lever G, which the weaver himself causes to rise and fall, by means of a peculiar pedal; so that without the aid of any person, after the piece is properly read in and mounted, he can execute the most complex patterns, as easily as he could weave plain goods; only attending to the order of his weft yarns, when these happen to be of different colors.

If some warp yarns should happen to break without the weaver observing them, or should he mistake his colored shuttle yarns, which would so far disfigure the pattern, he must undo his work. For this purpose, he makes use of the lower hooked lever *f*, whose purpose is to make the chain of the card go backwards, while working the loom as usual, withdrawing at each stroke the shot both of the ground and of the figure. The weaver is the more subject to make mistakes, as the figured side of the web is downwards, and it is only with the aid of a bit of looking-glass that he takes a peep of his work from time to time. The upper surface exhibits merely loose threads in different points, according as the pattern requires them to lie upon the one side or the other.

Thus it must be evident, that such a number of paste-boards are to be provided and mounted as equal the number of throws of the shuttle between the beginning and end of any figure or design which is to be woven; the piercing of each paste-board individually, will depend upon the arrangement of the lifting rods, and their connexion with the warp, which is according to the design and option of the workman; great care must be taken that the holes come exactly opposite to the ends of the needles; for this purpose two large holes are made at the ends of the paste-boards, which fall upon conical points, by which means they are made to register correctly.

It will be hence seen, that, according to the length of the figure, so must be the number of paste-boards, which may be readily displaced so as to remount and produce the figure in a few minutes, or remove it, or replace it, or preserve the figure for future use. The machine, of course, will be understood to consist of many sets of the lifting rods and needles, shown in the diagram, as will be perceived by observing the disposition of the holes in the paste-board; those holes, in order that they may be accurately distributed, are to be pierced from a gauge, so that not the slightest variation shall take place.

To form these card-slips, an ingenious apparatus is employed, by which the proper steel punches required for the piercing of each distinct card, are placed in their relative situations preparatory to the operation of piercing, and also by its means a card may be punched with any number of holes at one operation. This disposition of the punches is effected by means of rods connected to cords disposed in a frame, in the nature of a false simple, in which the pattern of the work to be performed is first read in.

These improved pierced cards, slips, or paste-boards, apply to a weaving apparatus, which is so arranged that a figure to be wrought can be extended to any distance along the loom, and by that means the loom is rendered capable of producing broad figured works; having the long lever G placed in such a situation that it affords power to the foot of the weaver, and by this means enables him to draw the heaviest morintures and figured works, without the assistance of a draw-boy.

The machinery for arranging the punches, consists of a frame with four upright standards and cross-pieces, which contains a series of endless cords passing under a wooden roller at bottom, and over pulleys at the top. These pulleys are mounted on

axles in two frames, placed obliquely over the top of the standard frame, which pulley-frames constitute the table commonly used by weavers.

In order better to explain these endless cords, *fig.* 574 represents a single endless cord 1, 1, which is here shown in operation, and part of another endless cord 2, 2, shown
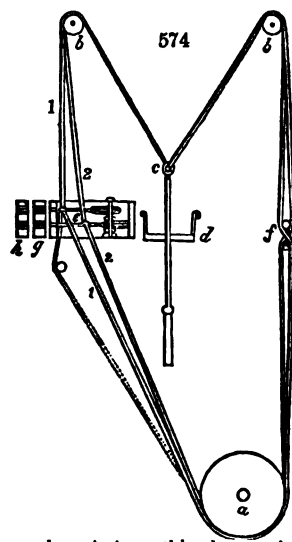
stationary. There must be as many endless cords in this frame as needles in the weaving-loom. *a* is the wooden cylinder, revolving upon its axis at the lower part of the standards; *b b*, the two pulleys of the pulley-frames above, over which the individual endless cord passes; *c* is a small traverse ring. To each of these rings a weight is suspended by a single thread, for the purpose of giving tension to the endless cord. *d* is a board resembling a common comber-bar, which is supported by the cross-bars of the standard frame, and is pierced with holes, in situation and number, corresponding with the perpendicular threads that pass through them; which board keeps the threads distinct from each other.

At *e*, the endless cord passes through the eyes of wires resembling needles, which are contained in a wooden box placed in front of the machine, and shown in this figure in section only. These wires are called the *punch-projectors;* they are guided and supported by horizontal rods and vertical pins, the latter of which pass through loops formed at the hinder part of the respective wires. At *f* are two horizontal rods extending the whole width of the machine, for the purpose of producing the cross in the cords; *g* is a thick brass plate, extending along in front of the machine, and lying close to the box which holds the *punch-projectors;* this plate *g*, shown also in section, is called the *punch-holder;* it contains the same number of apertures as there are punch-projectors, and disposed so as to correspond with each other. In each of these apertures, there is a punch for the purpose of piercing the cards, slips, or pasteboards with holes; *h* is a thick steel plate of the same size as *g*, and shown likewise in section, corresponding also in its number of apertures, and their disposition, with the punch-projectors and the punch-holder. This plate *h*, is called the *punch-receiver.*

The object of this machine is to transfer such of the punches as may be required for piercing any individual card from the punch-holder *g*, into the punch-receiver *h;* when they will be properly situated, and ready for piercing the individual card or slip, with such holes as have been read in upon the machine, and are required for permitting the warp threads to be withdrawn in the loom, when this card is brought against the ends of the needles. The process of transferring the patterns to the punches will be effected in the following manner.

The pattern is to be read in, according to the ordinary mode, as in a false simple, upon the endless cords below the rods *f*, and passed under the revolving wooden cylinder *a*, to a sufficient height for a person in front of the machine to reach conveniently. He there takes the upper threads of the pattern, called the *beard*, and draws them forward so as to introduce a stick behind the cords thus advanced, as shown by dots, for the purpose of keeping them separate from the cords which are not intended to be operated upon. All the punch-projectors which are connected with the cords brought forward, will be thus made to pass through the corresponding apertures of the punch-holder *g*, and by this means will project the punches out of these apertures, into corresponding apertures of the punch-receiver *h*. The punches will now be properly arranged for piercing the required holes on a card or slip, which is to be effected in the following manner.

Remove the punch-receivers from the front of the machine; and having placed one of the slips of card or pasteboard between the two folding plates of metal, completely pierced with holes corresponding to the needles of the loom, lay the punch-receiver upon those perforated plates; to which it must be made to fit by mortises and blocks, the cutting parts of the punches being downwards. Upon the back of the punch-receiver is then to be placed a plate or block, studded with perpendicular pins corresponding to the above described holes, into which the pins will fall. The plates and the blocks thus laid together, are to be placed under a press, by which means the pins of the block will be made to pass through the apertures of the punch-receiver; and wherever the punch has been deposited in the receiver by the above process, the said punches will be forced through the slip of pasteboard, and pierced with such holes as are required for producing the figured design in the loom.

Each card being thus pierced, the punch receiver is returned to its place in front of the machine, and all the punches forced back again into the apertures of the punch-holder as at first. The next set of cords is now drawn forward by the next *beard*, as above described, which sends out the *punch-projectors* as before, and disposes the punches in the punch-receiver, ready for the operation of piercing the next card. The process being thus repeated, the whole pattern is, by a number of operations, transferred to the punches, and afterwards to the cards or slips, as above described.

JADE, axe-stone (*Nephrite, Ceraunite,* Fr.), is a mineral commonly of a greenish color, compact, and of a fatty lustre. Spec. Grav. 2·95; scratches glass, is very tough; fuses into a white enamel. Its constituents are, silica, 50·5; alumina, 10; magnesia, 31; oxyde of iron, 5·50; oxyde of chrome, 0·05; water, 2·75. It comes from China, is used among rude nations for making hatchets; and is susceptible of being cut into any form.

JAPANNING, is a kind of varnishing or lackering, practised with excellence by the Japanese, whence the name. See VARNISH.

JASPER (*Jaspe calcedoine,* Fr.; *Jaspis,* Germ.) is a sub species of calcedony quartz, of which there are five varieties. 1. The Egyptian red and brown, with ring or tendril-shaped delineations. 2. Striped jasper. 3. Porcelain jasper. 4. Common jasper. 5. Agate jasper. The prettiest specimens are cut for seals, and for the inferior kinds of jewellery ornaments. See LAPIDARY.

ICE-HOUSE; (*Glacière,* Fr.; *Eishaus,* Germ.) Under the article FREEZING I have enumerated the different artificial methods of producing cold. But for the uses of common life, in these climates, the most economical and convenient means of refrigeration in hot weather may be procured by laying up a store of ice in winter, in such circumstances as will preserve it solid during summer.

An ice-house should not be regarded as an object of mere luxury, for pleasing the palates of gourmands with iced creams and orgeats. In the southern countries of Europe it is considered among people in easy circumstances as an indispensable appendage to a country mansion. During the Dog-days, especially at those periods and in those districts where the *sirocco* blows, a lassitude and torpor of mind and body supervene, with indigestion or total loss of appetite, and sometimes dysenteries, which are obviously occasioned by the excessive heat, and are to be prevented or counteracted chiefly by the use of cold beverages. By giving tone to the stomach, iced drinks immediately restore the functions of the nervous and muscular systems when they are languid; while they enable persons in health to endure without much inconvenience an atmosphere so close and sultry as would be intolerable without this remedy. Ice-houses, moreover, afford to country gentlemen a great advantage in enabling them to preserve their fish, butcher meat, dead poultry, and game, which would otherwise, in particular states of the weather, immediately spoil. Considering at how little expense and trouble an ice-house can be constructed, it is surprising that any respectable habitation in the country should not have one attached to it. The simplest and most scientific form is a double cone, that is, two cones joined base to base; the one being of stones or brickwork, sunk under ground with its apex at the bottom, into which the ice is rammed; the other being a conical roof of carpentry covered with thatch, and pointed at top. The entrance should be placed always on the north side; it should consist of a corridor or porch with double doors, and be screened from the sunbeams by a small shrubbery. Such are, in general, the principles upon which an ice-house should be formed; but they will be better understood by the following explanation and figure.

A dry sandy soil should be selected, and, if possible, a spot sheltered by a cliff or other natural barrier from the direct rays of the sun. Here a cavity is to be dug about 16 feet in diameter, terminating below like the point of a sugar loaf. Its ordinary depth, for a moderate family, may be about 24 feet; but the larger its dimensions are, the longer will it preserve the ice, provided it be filled. In digging, the workman should slope the ground progressively towards the axis of the cone, to prevent the earth falling in. This conical slope should be faced with brick or stone work about one foot thick, and jointed with Roman cement so as to be air and water tight. A well is to be excavated at the bottom two feet wide and four deep, covered at top with an iron grating for supporting the ice, and letting the water drain away.

The upper cone may likewise be built of brickwork, and covered with thatch; such a roof would prove the most durable. This is the construction shown in *fig.* 575. Whatever kind of roof be preferred, there must be left in it an oblong passage into the interior. This porch should face the north, and be at least 8 feet long by 2½ feet wide; and perfectly closed by a well-fitted door at each end. All round the bottom of this conical cover, a gutter should be placed to carry off the rain to a distance from the ice-house, and prevent the circumjacent ground from getting soaked with moisture.

Fig. 575 shows the section of a well-constructed ice-house. Under the ice-chamber A the ice is rammed into the space B. c is the grate of the drain-sink D. The

portion ʀ ʀ is built in brick or stone; the base ʟ of the ice-chamber slopes inwards towards the centre at c. The upper part of the brickwork ʀ ʀ is a little way below the level of the ground. The wooden frame work ғ ғ ғ ғ forms the roof, and is covered with thick thatch. ɢ ʜ is the wooden work of the door ʟ. At x the bucket is seen for lifting up a charge of ice, by means of the cord ɪ passing over the pulley x, which enables the servant to raise it easily.
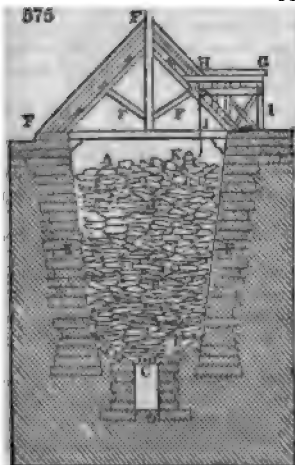
The icehouse should have no window to admit light; but be, so to speak, hermetically sealed in every point, except at its cess-pool, which may terminate in a water trap to prevent circulation of air.

A clear day should be selected for charging the icehouse; but before beginning to fill, a quantity of long dry straw should be laid on the bottom crosswise; and as the ice is progressively introduced, straw is to be spread against the conical sides, to prevent the ice from coming into contact with the brick or stone work. The more firmly compacted the ice is, the better does it keep; with which view it should be broken into pieces with mallets before being thrown in. No layers of straw should be stratified among the ice, for they would make its body porous. Some persons recommend to pour in a little water with the successive layers of ice, in order to fill up its small crevices, and convert the whole into one mass.

Over the top layer a thick bed of straw should be spread, which is to be covered with boards surmounted with heavy stones, to close up the interstices in the straw. The inner and outer doors should never be opened at once; but the one should always be shut before the other is opened.

Dry snow well rammed keeps equally well with hard ice, if care be taken to leave no cavities in the mass, and to secure its compactness by sprinkling a little water upon the successive charges.

To facilitate the extraction of the ice, a ladder is set up against its sloping wall at one side of the door, and left there during the season.

JELLY, VEGETABLE, of ripe currants and other berries, is a compound of mucilage and acid, which loses its power of gelatinizing by prolonged ebullition.

JELLY, ANIMAL; see GELATINE, GLUE, and ISINGLASS.

JET (*Jaiet* or *jais*, Fr.), a species of pitch-coal or glance-coal, which, being found abundantly in a beautiful compact form, in the valley of Hers, arrondissement of Pamiers, department of the Arriège, has been worked up extensively there from time immemorial, into a multitude of ornamental articles. With this black lignite, buttons, crosses, rosaries, necklaces, ear-drops, bracelets, waist-buckles, &c. are made, which were at one time much worn by ladies for mourning dresses. The greater number of these ornaments are fashioned upon grind-stones which turn in a horizontal direction, and are kept continually wet; others are turned at the lathe, or shaped by files.

About 40 years ago this manufacture employed from 1000 to 1200 operatives; at present it gives bread to only 60. This falling off may be ascribed to the successful imitation of the jet articles by those of black glass, which are equally beautiful, and not nearly so apt to lose their polish by use.

IMPERMEABLE, is the epithet given to any kind of textile fabric, rendered water proof by one or other of the following substances;—

1. Linseed oil to which a drying quality has been communicated by boiling with litharge or sugar of lead, &c.

2. The same oil holding in solution a little caoutchouc.

3. A varnish made by dissolving caoutchouc in rectified petroleum or naptha, applied between two surfaces of cloth, as described under Mackintosh's patent. See CAOUTCHOUC.

4. Vegetable or mineral pitch, applied hot with a brush, as in making tarpawling for covering goods in ships.

5. A solution of soap worked into cloth, and decomposed in it by the action of a solution of alum; whence results a mixture of acid fats and alumina, which insinuates itself among all the woolly filaments, fills their interstices, and prevents the passage of water.

6. A solution of glue or isinglass, introduced into a stuff, and then acted upon by a

clear infusion of galls, whereby the fibres get impregnated with an insoluble, impermeable, pulverulent leather.

7. Plaster work is rendered impermeable by mixing artificial or natural asphaltum with it.

JEWELLERY, *Art of.* See GEM and LAPIDARY.

INCOMBUSTIBLE CLOTH is a tissue of the fibrous mineral called amianthus or asbestos. This is too rare to form the object of any considerable manufacture. Cotton and linen cloth may be best rendered incapable of taking fire, or burning with flame, by being imbued with a solution of sal ammoniac.

INCUBATION, ARTIFICIAL. The Egyptians have from time immemorial been accustomed to hatch eggs by artificial warmth, without the aid of hens, in peculiar stoves, called *Mammals.* The inhabitants of the village Bermé still travel through the most distant provinces of Egypt at certain seasons of the year, with a portable furnace, heated by a lamp, and either hatch chickens for sale, or undertake to hatch the eggs belonging to the natives at a certain rate per dozen. M. de Reaumur published in France, about a century ago, some ingenious observations upon this subject; but M. Bonnemain was the first person who studied with due attention all the circumstances of artificial incubation, and mounted the process successfully upon the commercial scale. So far back as 1777 he communicated to the Academy of Sciences an interesting fact, which he had noticed, upon the mechanism employed by chicks to break their shells; and for some time prior to the French revolution he furnished the Parisian market with excellent poultry at a period of the year when farmers had ceased to supply it. His establishment was ruined at that disastrous era, and no other has ever since been constructed or conducted with similar care. As there can be no doubt however of the practicability and profitableness of the scheme, when judiciously managed, I shall insert a brief account of his ingenious arrangements. I had the pleasure of making the acquaintance of this amiable old man at my first visit to Paris, many years ago, and believe all his statements to be worthy of credit. Some imitations of his plans have been made in this country, but how far they have succeeded, in an economical point of view, it is difficult to determine. His apparatus derives peculiar interest from the fact that it was founded upon the principle of the circulation of hot water, by the intestine motions of its particles, in a returning series of connected pipes; a subject afterwards illustrated in the experimental researches of Count Rumford. It has of late years been introduced as a *novelty* into this country, and applied to warm the apartments of many public and private buildings. The following details will prove that the theory and practice of hot water circulation were as perfectly understood by M. Bonnemain, fifty years ago, as they are by any of our stove-doctors at the present day. They were then publicly exhibited at his residence in Paris, and were afterwards communicated to the world at large in the interesting article of the *Dictionnaire Technologique*, entitled *Incubation Artificielle*.

The apparatus of M. Bonnemain consisted: 1. of a boiler and pipes for the circulation of water; 2. of a regulator calculated to maintain an equable temperature; 3. of a stove-apartment, heated constantly to the degree best fitted for incubation, which he called the *hatching* pitch. He attached to one side a *poussinière* or chick-room, for cherishing the chickens during a few days after incubation.

The boiler is represented in vertical section and ground plan, in *figs.* 576 and 577. It is composed of a double cylinder of copper or cast-iron, *l l*, having a grate, *b* (see plan), an ashpit at *d* (section). The water occupies the shaded
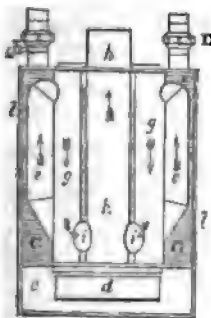
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space c, c. *h, g, g, e, e,* are five vertical flues, for conducting the burnt air and smoke, which first rise in the two exterior flues *e, e,* then descend in the two adjoining flues *g, g,* and finally re-mount through the passages *i, i,* in the central flue *h.* During this upwards and downwards circulation, as shown by the arrows in the section, the products of combustion are made to impart nearly the whole of their heat to the water by which they are surrounded. At the commencement, some burning paper or wood shavings are inserted at the orifice *m,* to establish a draught in this circuitous chimney. The air is admitted into the ashpit at the side, in regulated quantities, through a small square door, moveable round a rod which runs horizontally along its middle line. This swing valve is acted upon by an expanding bar (see HEAT-REGULATOR), which opens it more or less, according to the temperature of the stove apartment in which the eggs are placed.

D is the upper orifice of the boiler, by which the hotter and consequently lighter particles of the water continually ascend, and are replaced by the cooled particles, which enter the boiler near its bottom, as shown in *fig.* 578, at *n*. Into further details relative to the boiler it is needless to enter; for though its form, as designed by M. Bonnemain,

is excellent and most economical of heat for a charcoal fire, it would not suit one of pit-coal, on account of the obstruction to the pipes which would soon be occasioned by its soot.
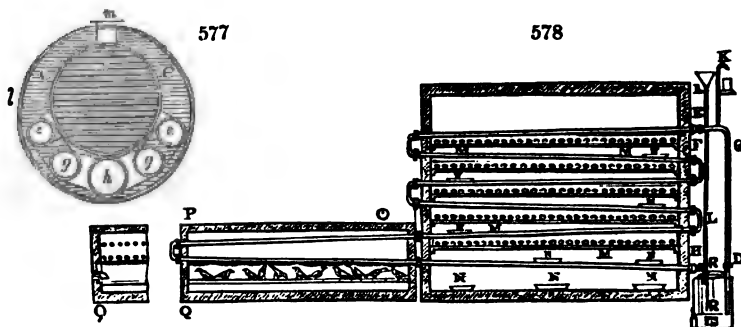
In *fig.* 578 the boiler is shown at R, with the rod which regulates the air door of the ashpit. D is a stopcock for modifying the opening by which the hotter particles of water ascend; G is the water-pipe of communication, having the heating pipe of distribution attached between E F, which thence passes backwards and forwards with a very slight slope from the horizontal direction, till it reaches the *poussinière* o P Q. It traverses this apartment, and returns by N N to the orifice of the boiler H, where it turns vertically downwards, and descends to nearly the bottom of the boiler, discharging at that point the cooled and therefore denser particles of water, to replace those which continually issue upwards at D. L R is a tube surmounted with a funnel for keeping the range of pipes always full of water; and K is a syphon orifice for permitting the escape of the disengaged air, which would otherwise be apt to occupy partially the pipes and obstruct the aqueous circulation.

The faster the water gets cooled in the serpentine tubes, the quicker its circulation will be, because the difference of density between the water at the top and bottom of the boiler, which is the sole cause of its movement, will be greater. N represents small saucers filled with water, to supply the requisite moisture to the heated air, and to place the eggs, arranged along the trays M M, in an atmosphere analogous to that under the body of the hen.

When we wish to hatch eggs with this apparatus, the fire is to be kindled in the boiler, and as soon as the temperature has risen to about 100° F., the eggs are introduced; but only one twentieth of the whole number intended, upon the first day; next day, a like number is laid upon the trays, and thus in succession for twenty days, so that upon the twenty-first day the eggs first placed may be hatched, for the most part, and we may obtain daily afterwards an equal number of chicks. In this way, regularity of care is established in the rearing of them.

During the first days of incubation, natural as well as artificial, a small portion of the water contained in the egg evaporates by the heat, through the shell, and is replaced by a like quantity of air, which is afterwards useful for the respiration of the animal. If the warm atmosphere surrounding the eggs were very dry, such a portion of the aqueous part of the eggs would evaporate through the pores of the shells as would endanger the future life of the chick *in ovo*. The transpiration from the body of the hen, as she sits upon her eggs, counteracts this desiccation in general; yet, in very dry weather, many hatching eggs fail from that cause, unless they be placed in moist decomposing straw. The water saucers N N are therefore essential to success in artificial incubation.

After the chickens are hatched they are transferred into the nursery, O Q, on the front side of which there is a small grated trough filled with millet seed. Small divisions are made between the broods of successive days, to enable the superintendent to vary their feeding to their age.

In order to supply an establishment of the common kind, where 100 eggs are to be hatched daily, a dozen of hens would be needed, and 150 eggs must be placed under them, as only two thirds in general succeed. At this rate, 4300 mothers would be required to sit. Now supposing we should collect ten times as many hens, or 43,000, we should not be able to command the above number of chickens, as there is seldom a tenth part of hens in a brooding state. Besides, there would be in this case no fewer than 720 hens every day coming out with a fresh brood of chickens, which would require a regiment of superintendents.

Artificial Incubation by means of Hot Mineral Waters.—This curious process is

described very briefly in a letter by M. D'Arcet. The following are extracts from this letter :—

" In June, 1825, I obtained chickens and pigeons at Vichy, by artificial incubation, effected through the means of the thermal waters of that place. In 1827 I went to the baths of Chaudes-Aigues, principally for the purpose of doing the same thing there. Finding the proprietor a zealous man, I succeeded in making a useful application of this source of heat to the production of poultry.

" The advantage of this process may be comprehended, when it is known that the invalids who arrive at Vichy, for instance in the month of May, find chickens only the size of quails; whereas, by this means, they may be readily supplied six months old.

" The good which may be done by establishing artificial incubation in places where hot springs exist is *incalculable* ; it may be introduced into these establishments without at all interfering with the medical treatment of patients, since the hatching would go on in winter, at a time when the baths for other purposes are out of use.

" There is no other trouble required in breeding chickens, by means of hot baths, than to break the eggs at the proper time; for, when the apartments are closed, the whole of the interior will readily acquire a sufficiently elevated and very constant temperature."

In addition to these details by M. D'Arcet, a letter was received from M. Felgeris, the proprietor of the baths at Chaudes-Aigues (Cantal), in which he describes the success he had in following M. D'Arcet's process. This consists in putting the eggs into a small basket, suspending it in one of the stove-rooms heated by the hot mineral water, and turning round the eggs every day. The very first trial was attended with success, and no failure was experienced in four repetitions of it.

INDIGO. This invaluable blue dye-stuff, for which no tolerable substitute has been found, was known to the ancients as a pigment under the name of *indicum*, whence its present denomination. In modern Europe, it first came into extensive use in Italy, but, about the middle of the 16th century, the Dutch began to import and employ it in considerable quantities. Its general introduction into the dye-houses of both England and France was kept back by absurd laws, founded upon an opinion that it was a fugitive substance, and even prejudicial to the fibre of wool. See DYEING, p. 419.

The plants which afford this dye-drug grow in the East and West Indies, in the middle regions of America, in Africa, and Europe. They are all species of the genera *Indigofera, Isatis,* and *Nerium.*

The following are cultivated :—*Indigofera tinctoria* affords in Bengal, Malabar, Madagascar, the Isle of France, and St. Domingo, an article of middling quality, but in large quantity. The *indigofera disperma*, a plant cultivated in the East Indies and America, grows higher than the preceding, is woody, and furnishes a superior dye stuff. The Guatimala indigo comes from this species. *Indigofera Anil* grows in the same countries, and also in the West Indies. The *Indigofera Argentea*, which grows also in Africa; it yields little indigo, but of an excellent quality. *Indigofera Pseudo-tinctoria*, which is cultivated in the East Indies, furnishes the best of all : the *Indigofera Glauca* is the Egyptian and Arabian species. There are also the *cærulea, cinerea erecta, hirsuta, glabra,* and several others. The *Nerium tinctorium* of the East Indies affords some indigo; as does the *Isatis tinctoria,* or Woad, in Europe; and the *Polygonum tinctorium.*

The districts of Kishenagar, Jessore, and Moorshedabad, in Bengal, ranging from 88° to 90° E. L. and 22¼° to 24° N. L., produce the finest indigo. That from the districts about Burdwan and Benares is of a coarser or harsher grain. Tyroot, in lat. 26°, yields a tolerably good article. The portion of Bengal most propitious to the cultivation of indigo lies between the river Hoogly and the main stream of the Ganges.

In the East Indies, after having ploughed the ground in October, November, and the beginning of December, they sow the seed of the indigo plant in the last half of March and the beginning of April, while the soil, being neither too hot nor too dry, is most propitious to its germination. A light mould answers best; and sunshine, with occasional light showers, are most favorable to its growth. Twelve pounds of seeds are sufficient for sowing an acre of land. The plants grow rapidly, and will bear to be cut for the first time at the beginning of July, nay, in some districts, so early as the middle of June. The indications of maturity are the bursting forth of the flower buds, and the expansion of the blossoms; at which period the plant abounds most in the dyeing principle. Another indication is taken from the leaves; which, if they break across, when doubled flat, denote a state of maturity. But this character is somewhat fallacious, and depends upon the poverty or richness of the soil. When much rain falls, the plants grow too rapidly, and do not sufficiently elaborate the blue pigment. Bright sunshine is most advantageous to its production.

The first cropping of the plants is the best; after two months a second is made; after another interval, a third, and even a fourth; but each of these is of diminished value. There are only two croppings in America.

Two methods are pursued to extract the indigo from the plant; the first effects it by fermentation of the fresh leaves and stems; the second, by maceration of the dried leaves; the latter process being most advantageous.

1. *From the recent leaves.*—In the indigo factories of Bengal there are two large stone-built cisterns, the bottom of the first being nearly upon a level with the top of the second, in order to allow the liquid contents to be run out of the one into the other. The uppermost is called the fermenting vat, or the steeper; its area is 20 feet square, and its depth 3 feet; the lowermost, called the beater or beating vat, is as broad as the other, but one third longer. The cuttings of the plant, as they come from the field, are stratified in the steeper, till this be filled within 5 or 6 inches of its brim. In order that the plant, during its fermentation, may not swell and rise out of the vat, beams of wood and twigs of bamboo are braced tight over the surface of the plants, after which water is pumped upon them till it stands within three or four inches of the edge of the vessel. An active fermentation speedily commences, which is completed within 14 or 15 hours; a little longer or shorter, according to the temperature of the air, the prevailing winds, the quality of the water, and the ripeness of the plants. Nine or ten hours after the immersion of the plant, the condition of the vat must be examined; frothy bubbles appear, which rise like little pyramids, are at first of a white color, but soon become gray-blue, and then deep purple-red. The fermentation is at this time violent, the fluid is in constant commotion, apparently boiling, innumerable bubbles mount to the surface, and a copper-colored dense scum covers the whole. As long as the liquor is agitated, the fermentation must not be disturbed; but when it becomes more tranquil, the liquor is to be drawn off into the lower cistern. It is of the utmost consequence not to push the fermentation too far, because the quality of the whole indigo is deteriorated; but rather to cut it short, in which case there is, indeed, a loss of weight, but the article is better. The liquor possesses now a glistening yellow color, which, when the indigo precipitates, changes to green. The average temperature of the liquor is commonly 85° Fahr.; its specific gravity at the surface is 1·0015; and at the bottom, 1·003.

As soon as the liquor has been run into the lower cistern, ten men are set to work to beat it with oars, or shovels 4 feet long, called *busquets*. Paddle wheels have also been employed for the same purpose. Meanwhile two other laborers clear away the compressing beams and bamboos from the surface of the upper vat, remove the exhausted plant, set it to dry for fuel, clean out the vessel, and stratify fresh plants in it. The fermented plant appears still green, but it has lost three fourths of its bulk in the process, or from 12 to 14 per cent. of its weight, chiefly water and extractive matter.

The liquor in the lower vat must be strongly beaten for an hour and a half, when the indigo begins to agglomerate in flocks, and to precipitate. This is the moment for judging whether there has been any error committed in the fermentation; which must be corrected by the operation of beating. If the fermentation has been defective, much froth rises in the beating, which must be allayed with a little oil, and then a reddish tinge appears. If large round granulations are formed, the beating is continued, in order to see if they will grow smaller. If they become as small as fine sand, and if the water clears up, the indigo is allowed quietly to subside. Should the vat have been over fermented, a thick fat-looking crust covers the liquor, which does not disappear by the introduction of a flask of oil. In such a case the beating must be moderated. Whenever the granulations become round, and begin to subside, and the liquor clears up, the beating must be discontinued. The froth or scum diffuses itself spontaneously into separate minute particles, that move about the surface of the liquor; which are marks of an excessive fermentation. On the other hand, a rightly fermented vat is easy to work; the froth, though abundant, vanishes whenever the granulations make their appearance. The color of the liquor, when drawn out of the steeper into the beater, is bright green; but as soon as the agglomerations of the indigo commence, it assumes the color of Madeira wine; and speedily afterwards, in the course of beating, a small round grain is formed, which, on separating, makes the water transparent, and falls down, when all the turbidity and froth vanish.

The object of the beating is three-fold: first, it tends to disengage a great quantity of carbonic acid present in the fermented liquor; secondly, to give the newly developed indigo its requisite dose of oxygen by the most extensive exposure of its particles to the atmosphere; thirdly, to agglomerate the indigo in distinct flocks or granulations. In order to hasten the precipitation, lime-water is occasionally added to the fermented liquor in the progress of beating, but it is not indispensable, and has been supposed capable of deteriorating the indigo. In the front of the beater a beam is fixed upright, in which three or more holes are pierced a few inches in diameter. These are closed with plugs during the beating, but, two or three hours after it, as the indigo subsides, the upper plug is withdrawn to run off the supernatant liquor, and then the lower plugs in succession. The state of this liquor being examined, affords an indication of

the success of both the processes. When the whole liquor is run off, a laborer enters the vat, sweeps all the precipitate into one corner, and empties the thinner part into a spout which leads into a cistern, alongside of a boiler, 20 feet long, 3 feet wide, and 3 deep. When all this liquor is once collected, it is pumped through a bag for retaining the impurities, into the boiler, and heated to ebullition. The froth soon subsides, and shows an oily looking film upon the liquor. The indigo is by this process not only freed from the yellow extractive matter, but is enriched in the intensity of its color, and increased in weight. From the boiler the mixture is run, after two or three hours, into a general receiver called the *dripping vat*, or table, which, for a factory of twelve pairs of preparation vats, is 20 feet long, 10 feet wide, and 3 feet deep; having a false bottom, 2 feet under the top edge. This cistern stands in a basin of masonry (made water tight with Chunam hydraulic cement), the bottom of which slopes to one end, in order to facilitate the drainage. A thick woollen web is stretched along the bottom of the inner vessel, to act as a filter. As long as the liquor passes through turbid, it is pumped back into the receiver. Whenever it runs clear, the receiver is covered with another piece of cloth to exclude the dust, and allowed to drain at its leisure. Next morning the drained magma is put into a strong bag, and squeezed in a press. The indigo is then carefully taken out of the bag, and cut with a brass wire into bits, about 3 inches cube, which are dried, in an airy house, upon shelves of wicker work. During the drying, a whitish efflorescence comes upon the pieces, which must be carefully removed with a brush. In some places, particularly on the coast of Coromandel, the dried indigo lumps are allowed to effloresce in a cask for some time, and when they become hard they are wiped and packed for exportation.

From some experiments it would appear that the gas disengaged during the middle period of the fermentation is composed in 100 parts of 27·5 carbonic acid, 5·8 oxygen, and 66·7 azote; and towards its end, of 40·5 carbonic acid, 4·5 oxygen, and 55·0 azote. The fermenting leaves apparently convert the oxygen of the atmosphere into carbonic acid gas, and leave its azote; besides the quantity of carbonic acid which they spontaneously evolve. Carbureted hydrogen does not seem to be disengaged. That the liquor in the beating vat absorbs oxygen from the air in proportion as the indigo becomes flocculent and granular, has been ascertained by experiment, as well as that sunshine accelerates the separation of the indigo blue. Out of 1000 parts of the fermented liquor of specific gravity 1·003, the blue precipitate may constitute 0·75 of a part. Such a proportion upon the great scale is however above the average, which is not more than 0·5. When lime water is added, an extractive matter is thrown down, which amounts to from 20 to 47 parts in 1000 of the liquor. It has a dark brown tint, a viscid appearance, an unpleasant smell, and a bitter taste. It becomes moist in damp air, and dissolves in water without decomposition. It is precipitated by lime, alkalis, infusion of galls, and acetate of lead. All indigo contains a little lime derived from the plant, even though none has been used in its preparation.

2. *Indigo from dried leaves.*—The ripe plant being cropped, is to be dried in sunshine from 9 o'clock in the morning till 4 in the afternoon, during two days, and thrashed to separate the stems from the leaves, which are then stored up in magazines till a sufficient quantity be collected for manufacturing operations. The newly dried leaves must be free from spots, and friable between the fingers. When kept dry, the leaves undergo, in the course of 4 weeks, a material change, their beautiful green tint turning into a pale blue-gray, previous to which the leaves afford no indigo by maceration in water, but subsequently a large quantity. Afterwards the product becomes less considerable.

The following process is pursued to extract indigo from the dried leaves. They are infused in the steeping vat with six times their bulk of water, and allowed to macerate for two hours with continual stirring till all the floating leaves sink. The fine green liquor is then drawn off into the beater vat, for if it stood longer in the steeper, some of the indigo would settle among the leaves and be lost. Hot water, as employed by some manufacturers, is not necessary. The process with dry leaves possesses this advantage, that a provision of the plant may be made at the most suitable times, independently of the vicissitudes of the weather, and the indigo may be uniformly made; and moreover, that the fermentation of the fresh leaves, often capricious in its course, is superseded by a much shorter period of simple maceration.

The process for obtaining indigo from the *Nerium* is altogether the same, but hot water has been generally applied to the dried leaves. For woad, hot water must be employed, and also lime water as a precipitant, on account of the small proportion of indigo in the plant. Dilute muriatic acid is digested upon the woad indigo to remove the lime, without which no dye could be precipitated. According to the warmth of the summer and the ripeness of the plant, from 2 to 5 ounces of indigo may be obtained from 100 pounds of the dried woad, or upon an average 4 ounces to the hundred weight.

The indigo found in European commerce is imported from Bengal, Coromandel, Madras, the Mauritius, Manilla, and Java in the Eastern hemisphere; from Senegal,

Caraccas, Guatimala, Brazil (South Carolina and Louisiana in small quantity), and formerly from the West India islands, especially St. Domingo. Its quality depends upon the species of the plant, its ripeness, the soil and climate of its growth, and mode of manufacture. The East Indian and Brazilian indigo comes packed in chests, the Guatimala in ox-hides, called *surons*.

The organ which affords the indigo is confined entirely to the pellicle of the leaves, and exists in largest quantity at the commencement of maturation while the plant is in flower. The indigofera is remarkable for giving a blue tinge to the urine of cows that feed upon its leaves.

According to some manufacturers, the plants should be cut down in dry weather, an hour or two before sunset, carried off the field in bundles, and immediately spread upon a dry floor. Next morning the reaping is resumed for an hour and a half, before the sun acts too powerfully upon vegetation; and the plants are treated in the same way. Both cuttings become sufficiently dry by 3 o'clock in the afternoon, so as to permit the leaves to be separated from the stems by thrashing. They are now thoroughly dried in the sunshine, then coarsely bruised, or sometimes ground to powder in a mill, and packed up for the operations of manufacture.

In the spring of 1830 I subjected a variety of specimens of indigo to comparative analyses, by dissolving a few grains of each in strong sulphuric acid, diluting the solutions with an equal volume of water, and determining the resulting shade of color in a hollow prism of plate glass, furnished with a graduated scale. The following are the results, compared to the shade produced by a like weight of absolute indigo.

I. East India Indigos; prices as at the last October sales.

No.	Price.		Real Indigo in 100 parts.	Characters by the Brokers.
	s.	*d.*		
1	3	9	42	Broken, middling violet, and coppery violet spotted.
2	3	6	56·5	Ditto, a little being coppery violet and copper.
3	3	3	46·0	Ditto, middling red violet, dull violet and lean.
4	4	3	54·5	Large broken, and square, even middling red violet.
5	4	2	75·0	Much broken and very small, very crumbly and limy, soft, good violet.
6	4	9	60·0	Square and large broken, $\frac{1}{2}$ middling violet, and $\frac{1}{2}$ good coppery violet.
7	5	3	70·0	Large broken, very good; paste a little limy, good violet.
8	6	6	60·0	Square and large broken, soft, fine paste, fine violet.
9	6	0	66$\frac{2}{3}$	Square, ditto, good red violet.
10	7	0	75	Square, ditto, fine purple and blue.
11	2	3	37·5	Middling ordinary Madras.
12	3	6	60·0	Good Madras.
13	4	3	58·0	Very fine ditto.
14	2	0	——	Low, pale Oude.
15	2	4	27$\frac{2}{4}$	Middling, ordinary Oude.
16	3	3	54	Good Oude.
17	1	9	29	Lundy, very low quality.

II. American Indigos; wholesale prices at present.   (March, 1830.)

Indigo.	No.	Price.		Parts in 100.	Indigo.	No.	Price.		Parts in 100.
		s.	*d.*				*s.*	*d.*	
Caraccas flor. - -	1	6	0	54$\frac{1}{2}$	Guatimala - - -	6	5	0	50
Guatimala - - -	2	5	0	33$\frac{1}{2}$	—	7	5	3	35
—	3	3	2	19	—	8	4	8	46
—	4	4	6	32$\frac{1}{2}$	—	9	4	8	33$\frac{1}{2}$
—	5	5	4	50	—	10	5	4	50

Properties of Indigo.—It possesses a dark blue color, passing into violet-purple, is void of taste and smell, dull, but by rubbing with a smooth hard body, it assumes the lustre and hue of copper. It occurs sometimes less and sometimes more dense *apparently* than water, which circumstance depends upon its freedom from foreign impurities, as well as upon the treatment of its paste in the boiling, pressing, and drying operations. It is insoluble in water, cold alcohol, ether, muriatic acid, dilute sulphuric acid, cold

ethereous and fat oils; but boiling alcohol and oils dissolve a little of it, which they deposite on cooling. Creosote has the property of dissolving indigo.

Indigo is a mixture of several dye-stuffs, and other substances. Berzelius found in it a matter resembling vegetable gluten or gliadine, a brown, red, and blue pigment, besides oxyde of iron, clay, lime, magnesia, and silica.

1. Indigo gluten or gliadine is dissolved along with the calcareous and magnesian salts by acids. If the powder be treated with dilute sulphuric acid, if the solution be saturated with carbonate of lime, evaporated to dryness, and its residuum treated with alcohol; the solution thus formed leaves, after being evaporated, a yellow transparent extract, easily soluble in water, more difficultly in acid liquids; showing that acids extract only a portion of the gliadine from the indigo. It yields, by dry distillation, much ammonia, a fetid oil, and comports itself in other respects like vegetable gluten.

2. *Indigo-brown* occurs in combination with lime, as also with vegetable acid in considerable quantity, and more abundantly in the coarser sorts of indigo than in the finer. Indigo purified by acids is to be treated with hot strong caustic ley, which dissolves the indigo-brown; the liquid part of the mixture passes with difficulty through the filter, is black-brown, opaque, and holds some indigo-blue in solution, or diffused in fine powder. The alkali being neutralized with acetic acid, the liquor is to be evaporated, and alcohol poured on the residuum, whereby the alkaline acetate is dissolved out from the brown.

This pigment is a dark brown, almost black, but is not yet entirely deprived of the other constituents of indigo. It is nearly tasteless, is combustible, affords, by dry distillation, ammonia and fetid oil, forms with acids combinations hardly soluble in water, with alkalis soluble ones, but with earths hardly soluble. Lime possesses the property of precipitating the indigo-brown completely from its alkaline solution. Chlorine occasions a pale yellow brownish precipitate, which consists of indigo brown and muriatic acid, but causes no further change. By drying, it becomes again dark colored. Indigo-brown seems to exist also in woad.

3. *Indigo-red*, or more properly red resin of indigo. This may be obtained by boiling alcohol of sp. grav. 0·830 upon some indigo which has been previously treated with acids and alkalis; for the red substance is hardly soluble in cold alcohol. The solution is dark red, opaque, and leaves, by distillation, the indigo-red in the form of a black-brown powder, or a glistening varnish, slightly soluble in alcohol and ether. Alkalis do not dissolve it, but concentrated sulphuric acid forms with it a dark yellow dye, from which water causes no precipitation; wool extracts the color from the acid solution, and becomes of a dirty brown hue. Chlorine does not seem capable of destroying the color, for though it makes it yellow, it becomes as dark as ever on being dried. Indigo-red melts with heat, burns with a bright flame, affords, when heated in vacuo, first a white crystalline sublimate, and then unchanged indigo-red. That white matter is changed by nitric acid into indigo-red.

4. *Indigo-blue*, or pure indigo, remains, after treating the indigo of commerce with dilute acid, alkalis, and alcohol; it retains, however, still traces of the matters thereby extracted, along with some earthy substances. In order to procure indigo-blue in its utmost purity, we must deoxydize the above blue residuum, thus form colorless indigo, which again acquires a blue color from the air, and constitutes the pure pigment. For this purpose the above moist indigo is to be mixed with slaked lime, green sulphate of iron, and hot water in an air-tight matrass. The indigo when deoxydized by protoxyde of iron being soluble in lime-water, the clear yellow solution is to be poured off, and exposed to the air. The indigo absorbs oxygen, and becomes again blue. By digestion with dilute muriatic acid the foreign matters are dissolved, and may then be washed away with distilled water, from the *absolute* indigo.

The indigo-blue obtained in this manner has a cast of purple red, displaying the characteristic copper lustre in a high degree, but in powder, it is blue. It is void of taste and smell, is by my experiments of specific gravity 1·50, affords at 554° Fahr. a purple vapor, and sublimes in shining purple scales, or slender needles in an apparatus open to the air, whereby, however, much of it is destroyed. Some carbon remains after the sublimation. A quick heat produces most sublimate. These needles contain a brown oily matter, which may be dissolved out by means of hot alcohol. Their specific gravity is 1·35, according to Mr. Crum. The sublimate from common indigo does not contain any oil, but some indigo-red and the above white crystalline matter. According to Mr. Crum, indigo-blue consists of carbon, 73·22; oxygen, 12·60; azote, 11·26; hydrogen, 2·92; while according to Dumas, crystallized indigo consists of carbon, 73·26; oxygen, 10·43; azote, 13·81; and hydrogen, 2·50; precipitated indigo consists of carbon, 74·81; oxygen, 7·88; azote, 13·98; and hydrogen, 3·33; sublimed indigo, of carbon, 71·71; oxygen, 12·18; azote, 13·45; hydrogen, 2·66. My own analysis afforded—carbon, 71·37; oxygen, 14·25; azote, 10·00; hydrogen, 4·38. In another analysis of Dumas, 3·93 parts of hydrogen were obtained. Hence we must infer that considerable differences exist in the composition of indigo in its purest state. Reagents

act upon it much as upon common indigo. Chlorine, iodine, and bromine convert it into a reddish brown soluble substance. Concentrated sulphuric acid, especially the smoking or anhydrous of Nordhausen, dissolves indigo-blue with the disengagement of heat, but it makes it suffer some modification; for though it retains an intense dark blue color, it has become soluble in water, and may be blanched by light, which does not happen with indigo itself. Nitric acid destroys indigo-blue, forms indigotic (carbazotic) acid, carbonic acid, artificial resin, and bitter principle.

Indigo-blue may be reduced by substances oxydized, with the co-operation of alkalis or alkaline earths; for example, by such substances as have a strong affinity for oxygen, and are imperfectly saturated with this principle, as the sulphurous and phosphorous acids and their salts, the protoxydes of iron and manganese, the protoxyde salts of tin, and the corresponding compounds of chlorine, as the proto-chlorides of tin and iron; and the solution of the former in potash. When in these circumstances, in the presence of alkali, a deoxydation or reduction of the indigo-blue takes place, the other bodies get oxydized by absorption of the oxygen of the indigo-blue; the protoxydes become per-oxydes, and the acids in *ous* become acids in *ic*, &c. Several metallic sulphurets also reduce the indigo-blue in the same predicament, as the sulphurets of potassium, of cal-cium, of antimony, and of arsenic (orpiment.) A similar influence is exercised by fer-menting vegetable substances, such as woad, madder, bran, raw sugar (molasses), starch, sirup, in consequence of the formation of carbonic and acetic acids, by absorption of the oxygen of the indigo-blue, for acetic acid and acetic salts are found in the liquor of the warm blue vat, in which indigo has been reduced by means of woad, madder, and bran.

Formation of colorless reduced indigo-blue, or indigotine.—Purified indigo-blue is to be treated with copperas and slaked lime, as above described; or the clear wine-yellow supernatant liquor of the cold blue-vat mixture is to be taken, run by a syphon into a matrass, a few drops of concentrated acetic or sulphuric acid, deprived of air, are to be poured into it, and the vessel, being made quite full, is to be well corked. The reduced indigo soon falls in white flocks, or crystalline scales. They must be edulcorated upon a filter with water deprived of its air by boiling, then pressed between folds of blotting-paper, and dried under the receiver in vacuo. Indigo-blue may likewise be reduced and dissolved by solution of hydro-sulphuret of ammonia; and the colorless indigotine may be precipitated by muriatic acid.

The reduced indigo is sometimes white at the instant of its elimination, sometimes grayish, of a silky lustre, but becomes very readily greenish, blue green, and blue, in the air; in which case it absorbs, according to Berzelius, 4·2 per cent. of oxygen; but ac-cording to Liebeg, 11·5 per cent. It is void of taste and smell, is insoluble in water; well boiled water free from air is not affected by it, but is turned blue by common water. It dissolves in alcohol and ether into a yellow dye; not in dilute acids, but in concen-trated sulphuric acid, whereby probably a portion of this is decomposed, and some hypo-sulphurous acid formed; the color of this solution is blue. Solutions of the caustic and carbonated alkalis, even the alkaline earths, readily dissolve reduced indigo into a wine-yellow liquid; but in contact with air, oxygen is absorbed, and indigo-blue falls, while a purple-colored froth, passing into copper-red, appears upon the surface, just as in the indigo vats of the dyer.

The reduced indigo may be combined, by means of complex affinity, with other bases, with the exception of the oxydes of copper, zinc, and mercury, which oxydize it. These combinations are white, in part crystallizable, become speedily blue in the air, and afford by sublimation indigo-blue. Berzelius formed with lime a two-fold combination; one easily soluble in water, and another difficultly soluble, of a lemon color, which contained an excess of lime; this is formed both in the hot and the cold blue vat; in the latter it is occasioned by an overdose of lime.

When pure indigo-blue is treated with concentrated sulphuric acid, and particularly with six times its weight of the smoking *dry* acid, it dissolves completely, and several different compounds are produced in the solution. There is first a blue sulphate of indigo; secondly, a similar compound with the resulting hyposulphurous acid; thirdly, a combination of sulphuric acid with the purple of indigo (called Phœnicin by Crum), a peculiar substance, generated from indigo-blue. These three compounds are here dissolved in an excess of sulphuric acid. The more concentrated the sulphuric acid is, the more blue hyposulphite is formed. The solution in smoking acid, when diluted with water and filtered, affords a considerable precipitate of indigo purple, which that in oil of vitriol does not. The vapor of anhydrous sulphuric acid combines with indigo-blue into a purple fluid.

In order to obtain from the dark blue solution each of these blue acids in a pure state, we must dilute it with forty times its weight of water, and immerse in the filtered liquor, well washed wool or flannel, with which the blue acids combine, while most of the sulphuric acid and some other foreign substances remain free in the liquor. The wool must be then scoured with water containing about a half per cent. of carbonate of am-monia, or potash, which neutralizes both of the blue acids, and produces a blue compound,

This being evaporated to dryness at the temperature of 140° F., alcohol of 0·833 is to be poured upon the residuum, which dissolves the blue hyposulphite, but leaves the blue sulphate undissolved. From either salt, by precipitating with acetate of lead, by acting upon the precipitate with sulphureted hydrogen water, and evaporation, either of the two blue acids may be obtained. They may be both evaporated to dryness, especially the blue sulphate of indigo; they both become somewhat moist in the air, they are very soluble in water, and the blue sulphate also in alcohol; they have a not unpleasant smell, and an acid astringent taste.

From these habitudes, particularly in reference to the bases, it appears that indigo-blue does not comport itself like a saline base towards the acids, but rather like an acid, since it enters into the salts, just as the empyreumatic oil of vinegar and oil of turpentine do into resin soaps. The blue pigment of both acids is reduced by zinc or iron without the disengagement of hydrogen gas; as also by sulphureted hydrogen, tepid protochloride of tin, while the liquor becomes yellow.

Indigo-blue sulphate of potash, or ceruleo-sulphate of potash, may be obtained by extracting the blue color from the wool by water containing 1 per cent. of carbonate of potash, evaporating nearly to dryness, treating the extract with alcohol to remove the *indigo-blue hyposulphite,* then with acetic acid and alcohol to remove any excess of carbonate of potash. It is found in commerce under the name of precipitated indigo, indigo paste, blue carmine, and soluble indigo. To prepare it economically, indigo is to be dissolved in ten times its weight of concentrated sulphuric acid; the solution after twenty-four hours is to be diluted with ten times its weight of water, filtered, and imperfectly saturated with carbonate of potash; whereby a blue powder falls down; for the resulting sulphate of potash throws down the ceruleo-sulphate, while the hyposulphite of potash remains dissolved. It is a dark blue copper shining powder, soluble in 140 parts of cold water, and in much less of boiling water. It is made use of as a dye, and to give starch a blue tint. When mixed with starch into cakes, it is sold under the name of *blue* for washerwomen.

Ceruleo-sulphate of ammonia may be formed in the same way. It is much more soluble in water. Ceruleo-sulphate of lime is obtained by saturating the above dilute acid with chalk, filtering to separate the undyed gypsum, and washing with water till the purple color be extracted. This liquor, evaporated and decomposed by alcohol, affords a bluish flocky precipitate, which is more soluble in water than common gypsum, and dries up in a purple-blue film. Ceruleo-sulphate of alumina may be obtained by double affinity; it is dark blue while moist, but becomes black-blue by drying, and is soluble in water.

The blue present in all these salts of *ceruline* is destroyed by sunshine, becomes greenish-gray by caustic alkalis; and turns immediately yellow-brown by alkaline earths. But when the solution is very dilute, the color becomes first green, then yellow. The carbonates of alkalis do not produce these changes. Nitric acid decomposes the color quickly. Mr. Crum considers ceruline to be a combination of indigo-blue with water.

Phenicine, or indigo-purple combined with sulphuric acid, is obtained when the solution of indigo-blue in concentrated sulphuric acid has been diluted for a few hours with water, and then filtered. It seems to be an intermediate body into which the indigo-blue passes, before it becomes soluble *ceruline.* Hence it occurs in greater quantity soon after digesting the indigo with the acid, than afterwards. It is dark blue, dissolves gradually in water, affords after evaporation a blue residuum, of the same appearance as the above blue acids. When a salt is added to it a purple precipitate ensues, which is a compound of indigo-purple, sulphuric acid, and the base of the salt. Indigo-purple is reduced by bodies having a strong attraction for oxygen, if a free alkali or alkaline earth be present, and its solution is yellow, but it becomes blue in the atmosphere. According to Mr. Crum, *Phenicine* contains half as much combined water as ceruline.

The table which I published in 1830 (as given above) shows very clearly how much the real quality and value of indigo differ from its reputed value and price, as estimated from external characters by the brokers. Various test or proof processes of this drug have been proposed. That with chlorine water is performed as follows. It is known that chlorine destroys the blue of indigo, but not the indigo-red or indigo-brown, which by the resulting muriatic acid is thrown down from the sulphuric solution in flocks, and the chlorine acts in the same way on the gliadine or gluten of the indigo. Pure indigo-blue is to be dissolved in 10 or 12 parts of concentrated sulphuric acid, and the solution is to be diluted with a given weight of water, as, for example, 1000 parts for 1 of indigo-blue. If we then put that volume of liquor into a graduated glass tube, and add to it chlorine water of a certain strength till its blue color be destroyed by becoming first green and then red-brown, we can infer the quantity of color from the quantity of chlorine water expended to produce the effect. The quantity of real indigo-blue cannot, however, be estimated with any accuracy in this way, because the other coloring matters in the drug act also upon the chlorine; and, indeed, the indigo itself soon changes when dissolved in

sulphuric acid, even out of access of light, while the chlorine water itself is very susceptible of alteration. Perhaps a better appreciation might be made by avoiding the sulphuric acid altogether, and adding the finely powdered indigo to a definite volume of the chlorine water till its color ceased to be destroyed, just as Prussian-blue is decolored by solution of potash in making the ferro-cyanide.

Another mode, and one susceptible of great precision, is to convert 10 or 100 grains of indigo finely powdered into its deoxydized state, as in the blue vat by the proper quantity of slaked lime and solution of green sulphate; then to precipitate the indigo, collect and weigh it. The indigo should be ground upon a muller along with the quick-lime, the levigated mixture should be diluted with water, and added to the solution of the copperas. This exact analytical process requires much nicety in the operator, and can hardly be practised by the broker, merchant, or manufacturer.

Employment of indigo in dyeing. — As indigo is insoluble in water, and as it can penetrate the fibres of wool, cotton, silk, and flax, only when in a state of solution, the dyer must study to bring it into this condition in the most complete and economical manner. This is effected either by exposing it to the action of bodies which have an affinity for oxygen superior to its own, such as certain metals and metallic oxydes, or by mixing it with fermenting matters, or, finally, by dissolving it in a strong acid, such as the sulphuric. The second of the above methods is called the warm blue, or pastel vat; and being the most intricate, we shall begin with it.

Before the substance indigo was known in Europe, woad having been used for dyeing blue, gave the name of woad vats to the apparatus. The vats are sometimes made of copper, at other times of iron or wood, the last alone being well adapted for the employment of steam. The dimensions are very variable; but the following may be considered as the average size: depth, 7½ feet; width below, 4 feet, above, 5 feet. The vats are built in such a way that the fire does not affect their bottom, but merely their sides half way up; and they are sunk so much under the floor of the dyehouse, that their upper half only is above it, and is surrounded with a mass of masonry to prevent the dissipation of the heat. About 3 or 3½ feet under the top edge an iron ring is fixed, called the *champagne* by the French, to which a net is attached in order to suspend the stuffs out of contact of the sediment near the bottom.

In mounting the vat the following articles are required : 1. woad prepared by fermentation, or woad merely dried, which is better, because it may be made to ferment in the vat, without the risk of becoming putrid, as the former is apt to do ; 2. indigo, previously ground in a proper mill; 3. madder ; 4. potash; 5. slaked quicklime ; 6. bran. In France, weld is commonly used instead of potash.

The indigo mill is represented in *figs.* 579 and 580. *a* is a four-sided iron cistern,

579   580
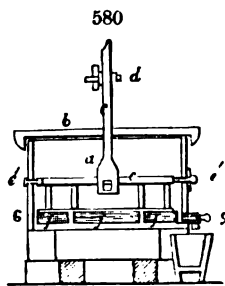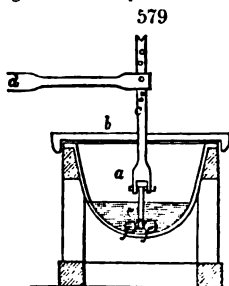
cylindrical or rounded in the bottom, which rests upon gudgeons in a wooden frame; it has an iron lid *b*, consisting of two leaves, between which the rod *c* moves to and fro, receiving a vibratory motion from the crank *d*. By this construction, a frame *e*, which is made fast in the cistern by two points *é é*, is caused to vibrate, and to impart its swing movement to six iron rollers *f f f*, three being on each side of the frame, which triturate the indigo mixed with water into a fine paste. Whenever the paste is uniformly ground, it is drawn off by the stopcock *g*, which had been previously filled up by a screwed plug, to prevent any of the indigo from lodging in the orifice of the cock, and thereby escaping the action of the rollers. The cistern is nearly three feet long.

The vat being filled with clear river water, the fire is to be kindled, the ingredients introduced, and if fermented woad be employed, less lime is needed than with the merely dried plant. Meanwhile the water is to be heated to the temperature of 160° Fahr., and maintained at this pitch till the deoxydizement and solution of the indigo begin to show themselves, which, according to the state of the constituents, may happen in 12 hours, or not till after several days. The first characters of incipient solution are blue

bubbles, called the flowers, which rise upon the surface, and remain like a head of soap-suds for a considerable time before they fall; then blue coppery shining veins appear with a like colored froth. The hue of the liquor now passes from blue to green, and an ammoniacal odor begins to be exhaled. Whenever the indigo is completely dissolved, an acetic smelling acid may be recognised in the vat, which neutralizes all the alkali, and may occasion even an acid excess, which should be saturated with quicklime. The time for doing this cannot be in general very exactly defined. When quicklime has been added at the beginning in sufficient quantity, the liquor appears of a pale wine-yellow color, but if not, it acquires this tint on the subsequent introduction of the lime. Experience has not hitherto decided in favor of the one practice or the other.

As soon as this yellow color is formed in the liquor, and its surface becomes blue, the vat is ready for the dyer, and the more lime it takes up without being alkaline, the better is its condition. The dyeing power of the vat may be kept up during six months, or more, according to the fermentable property of the woad. From time to time, madder and bran must be added to it, to revive the fermentation of the sediment, along with some indigo and potash, to replace what may have been abstracted in the progress of dyeing. The quantity of indigo must be proportional, of course, to the depth or lightness of the tints required.

During the operation of this blue vat two accidents are apt to occur; the first, which is the more common one, is called the *throwing back*, in French, the *cure rebuté*, and in German, the *Scharf* or *Schwartzwerden* (the becoming sharp or black); the second is the *putrefaction* of the ingredients. Each is discoverable by its peculiar smell, which it is impossible to describe. The first is occasioned by the employment of too much quick-lime, whereby the liquor becomes neutral or even alkaline. This fault may be recog-nised by the fading of the green, or by the dark green, or nearly black appearance of the liquor; and by a dull blue froth, owing to a film of lime. The remedy for a slight degree of this vicious condition, is to suspend in the liquor a quantity of bran tied up in a bag, and to leave it there till the healthy state be restored. Should the evil be more invete-rate, a decoction of woad, madder, and bran must be introduced. Strong acids are rather detrimental. Sulphate of iron has been recommended, because its acid precipitates the lime, while its oxyde reduces the indigo to the soluble state.

The decomposition or putrefaction of the blue vat is an accident the reverse of the preceding, arising from the transition of the acetous into the putrid fermentation, whereby the dyeing faculty is destroyed. Such a misfortune can happen only towards the com-mencement of working the vat, whilst the woad is still powerful, and very little indigo has been dissolved. Whenever the vat is well charged with indigo, that accident cannot easily supervene. In both of these distemperatures the elevation of the temperature of the vat aggravates the evil.

Dyeing in the blue vat is performed as follows :—

Wool is put into a net, and pressed down into the liquor with rods; but cloth is smoothly stretched and suspended by hooks upon frames, which are steadily dipped into the vat, with slight motions through the liquor; yarn-hanks must be dipped and turned about by hand. All unnecessary stirring of the liquor must however be avoided, lest the oxygen of the atmosphere be brought too extensively into contact with the reduced indigo, for which reason mechanical agitation with rollers in the vat is inadmissible. The stuffs to be dyed take at the first dip only a feeble color, though the vat be strong, but they must be deepened to the desired shade by successive immersions of fifteen minutes or more each time, with intervals of exposure to the air, for absorption of its oxygen.

After the lapse of a certain time, if the fermentative power be impaired, which is re-cognised by the dye stuffs losing more color in a weak alkaline test ley than they ought, the vat should be used up as far as it will go, and then the liquor should be poured away, for the indigo present is not in a reduced state, but merely mixed mechanically, and therefore incapable of forming a chemical combination with textile fibres. If cotton goods previously treated with an alkaline ley are to be dyed blue, the vat should contain very little lime.

Theory of the Indigo vat.—The large quantity of extractive matter in woad and madder, as also the sugar, starch, and gluten, in the bran and woad, when dissolved in warm water, soon occasion a fermentation, with an absorption of oxygen from the air, but especially from the indigo of the woad, and from that introduced in a finely ground state. When thus disoxygenated, it becomes soluble in alkaline menstrua; the red-brown of the indigo being dissolved at the same time. When lime is added, the indigo-blue dissolves, and still more readily if a little potash is conjoined with it; but whatever indigo-brown may have been dissolved by the potash, is thrown down by the lime. Lime in too large a quantity, however, forms an insoluble combination with the reduced indigo, and thus makes a portion of the dye ineffective; at the same time it combines with the extractive. In consequence of the fermentative action, carbonic acid, acetic acid, and ammonia are disengaged; the first two of which neutralize a portion of the lime,

and require small quantities of this earth to be added in succession; hence also a considerable quantity of the carbonate of lime is found as a deposite on the sides and bottom of the vat. In the sound condition of the indigo vat, no free lime should be perceived, but on the contrary a free acid. Yet when the disengaged carbonic and acetic acids saturate the lime completely, no indigo can remain at solution; therefore a sufficient supply of lime must always be left to dissolve the dye, otherwise the indigo would fall down and mix with the extractive matter at the bottom. Goods dyed in the blue vat are occasionally brightened by a boil in a logwood bath, with a mordant of sulpho-muriate of tin, or in a bath of cudbear.

Another mode of mounting the indigo vat without woad and lime, is by means of madder, bran, and potash. The water of the vat is to be heated to the temperature of 122° F.; and for 120 cubic feet of it, 12 pounds of indigo, 8 pounds of madder, and as much bran, are to be added, with 24 pounds of good potashes; at the end of 36 hours, 12 pounds more of potash are introduced, and a third 12 pounds in other 12 hours. In the course of 72 hours, all the characters of the reduction and solution of the indigo become apparent; at which time the fermentation must be checked by the addition of quicklime. The liquor has a bright full color, with a beautiful rich froth. In feeding the vat with indigo, an equal weight of madder, and a double weight of potash, should be added. The odor of this vat, in its mild but active state, is necessarily different from that of the woad vat, as no ammonia is exhaled in the present case, and the sediment is much smaller. The reduced indigo is held in solution by the carbonated potash, while the small addition of quicklime merely serves to precipitate the indigo-brown.

A potash vat dyes in about half the time of the ordinary warm vat, and penetrates fine cloth much better; while the goods thus dyed lose less color in alkaline and soap solutions. This vat may moreover be kept with ease in good condition for several months; is more readily mounted; and from the minute proportion of lime present, it cannot impair the softness of the woollen fibres. It is merely a little more expensive. It is said that cloth dyed in the potash indigo vat, requires one third less soap in the washing at the fulling mill, and does not soil the hands after being dressed. At Elbeuf and Louviers, in France, such vats are much employed. Wool, silk, cotton, and linen, may all be dyed in them.

Cold vats.—The *copperas* or *common blue vat* of this country is so named because the indigo is reduced by means of the protoxyde of iron. This salt should therefore be as free as possible from the red oxyde, and especially from any sulphate of copper, which would re-oxydize the indigo. The necessary ingredients are: copperas (green sulphate of iron), newly slaked quicklime, finely ground indigo, and water; to which sometimes a little potash or soda is added, with a proportional diminution of the lime. The operation is conducted in the following way: the indigo, well triturated with water or an alkaline ley, must be mixed with hot water in the *preparation* vat, then the requisite quantity of lime is added, after which the solution of copperas must be poured in with stirring. Of this *preparation* vat, such a portion as may be wanted is laded into the dyeing vat. For one pound of indigo three pounds of copperas are taken, and four pounds of lime (or 1 of indigo, $2\frac{1}{2}$ of copperas, and 3 of lime). If the copperas be partially peroxydized, somewhat more of it must be used.

A vat containing a considerable excess of lime is called a *sharp* vat, and is not well adapted for dyeing. A *soft* vat, on the contrary, is that which contains too much copperas. In this case the precipitate is apt to rise, and to prevent uniformity of tint in the dyed goods. The sediment of the copperas vat consists of sulphate of lime, oxyde of iron, lime with indigo brown, and lime with indigo blue, when too much quicklime has been employed. The clear, dark wine yellow fluid contains indigo blue in a reduced state, and indigo red, both combined with lime and with the gluten of indigo dissolved. After using it for some time the vat should be refreshed or fed with copperas and lime, upon which occasion the sediment must first be stirred up, and then allowed time to settle again and become clear. For obtaining a series of blue tints, a series of vats of different strengths is required.

Linen and cotton yarn, before being dyed, should be boiled with a weak alkaline ley, then put upon frames or tied up in hanks, and after removing the froth from the vat, plunged into and moved gently through it. For pale blues, an old, nearly exhausted vat is used; but for deep ones, a fresh, nearly saturated vat. Cloth is stretched upon a proper square dipping frame made of wood, or preferably of iron, furnished with sharp hooks or points of attachment. These frames are suspended by cords over a pulley, and thus immersed and lifted out alternately at proper intervals. In the course of 8 or 10 minutes, the cloth is sufficiently saturated with the solution of indigo, after which it is raised and suspended so as to drain into the vat. The number of dippings determines the depth of the shade; after the last, the goods are allowed to dry, taken off the frame, plunged into a sour bath of very dilute sulphuric or muriatic acid, to remove the adhering lime, and then well rinsed in running water. Instead of the dipping frames, some

dyers use a peculiar roller apparatus, called *gallopers*, similar to what has been described under CALICO PRINTING ; particularly for pale blues. This cold vat is applicable to cotton, linen, and silk goods.

When white spots are to appear upon a blue ground, resist pastes are to be used, as described under CALICO PRINTING.

The *urine vat* is prepared by digestion of the ground indigo in warmed stale urine, which first disoxygenates the indigo, and then dissolves it by means of its ammonia. Madder and alum are likewise added, the latter being of use to moderate the fermentation. This vat was employed more commonly of old than at present, for the purpose of dyeing woollen and linen goods.

The mode of making the China blue dye has been described under CALICO PRINTING ; as well as the *pencil blue*, or blue of application.

A blue dye may likewise be given by a solution of indigo in sulphuric acid. This process was discovered by Barth, at Grossenhayn, in Saxony, about the year 1740, and is hence called the Saxon blue dye. The chemical nature of this process has been already fully explained. If the smoking sulphuric acid be employed, from 4 to 5 parts are sufficient for 1 of indigo; but if oil of vitriol, from 7 to 8 parts. The acid is to be poured into an earthenware pan, which in summer must be placed in a tub of cold water, to prevent it getting hot, and the indigo, in fine powder, is to be added, with careful stirring, in small successive portions. If it becomes heated, a part of the indigo is decomposed, with the disengagement of sulphurous acid gas, and indigo green is produced. Whenever all the indigo has been dissolved, the vessel must be covered up, allowed to stand for 48 hours, and then diluted with twice its weight of clear river water.

The undiluted mass has a black blue color, is opaque, thick, attracts water from the air, and is called *indigo composition*, or *chemic blue*. It must be prepared beforehand, and kept in store. In this solution, besides the *cerulin*, there are also indigo-red, indigo-brown, and gluten, by which admixture the pure blue of the dye is rendered foul, assuming a brown or a green cast. To remove these contaminations, wool is had recourse to. This is plunged into the indigo previously diffused through a considerable body of water, brought to a boiling heat in a copper kettle, and then allowed to macerate as it cools for 24 hours. The wool takes a dark blue dye by absorbing the indigo-blue sulphate and hyposulphite, while at the same time the liquor becomes greenish blue; and if the wool be left longer immersed, it becomes of a dirty yellow. It must therefore be taken out, drained, washed in running water till this runs off colorless, and without an acid taste. It must next be put into a copper full of water, containing one or two per cent. of carbonate of potash, soda, or ammonia (to about one third the weight of the indigo), and subjected to a boiling heat for a quarter of an hour. The blue salts forsake the wool, leaving it of a dirty red-brown, and dye the water blue. The wool is in fact dyed with the indigo-red, which is hardly soluble in alkali. The blue liquor may now be employed as a fine dye, possessed of superior tone and lustre. It is called distilled blue and *soluble blue*. Sulphuric acid throws down from it the small quantity of indigo-red which had been held in solution by the alkali.

When wool is to be dyed with this sulphate of indigo-blue, it must be first boiled in alum, then treated with the blue liquor, and thus several times alternately, in order to produce a uniform blue color. Too long continuance of boiling is injurious to the beauty of the dye. In this operation the woollen fibres get impregnated with the indigo-blue sulphate of alumina.

With sulphate of indigo, not only blues of every shade are dyed, but also green, olive, gray, as also a fast ground to logwood blues; for the latter purpose the preparatory boil is given with alum, tartar, sulphates of copper and iron, and the blue solution; after which the goods are dyed up with a logwood bath containing a little potash.

STATISTICAL TABLES OF INDIGO; per favor of James Wilkinson, Esq., of Leadenhall Street.

EAST INDIA INDIGO.

Years.	Produce in India.	Consumption of the World ; average, 4 years.	Stock in England 31st December.	Highest Price.		Good middling Violet.			
				Per lb.					
	Chests.	*Chests.*	*Chests.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
1811	21,000	22,200	26,900	10	6	5	6	6	0
1812	23,500	22,500	29,500	11	6	6	9	7	3
1813	22,800	22,800	24,500	15	5	9	0	9	6
1814	28,500	23,000	24,900	13	0	7	9	8	3
1815	30,500	23,200	30,400	11	0	6	9	7	6
1816	25,000	26,900	25,700	10	0	5	0	5	8

East India Indigo.—*Continued.*

Years.	Produce in India.	Consumption of the World; average, 4 years.	Stock in England 31st December.	Highest Price.		Good middling Violet.			
1817	20,500	27,000	23,500	10	0	7	3	7	9
1818	19,100	26,500	24,000	9	3	6	9	7	3
1819	20,700	26,400	19,700	8	6	5	6	6	0
1820	27,200	24,200	14,500	9	0	6	3	6	9
1821	21,100	25,300	9,800	11	6	8	6	9	0
1822	25,700	26,000	8,200	12	0	9	0	9	6
1823	29,800	25,300	13,100	10	0	7	3	7	9
1824	24,100	26,500	12,200	15	0	12	0	12	6
1825	43,500	23,500	16,400	15	6	12	0	12	6
1826	28,000	27,300	22,300	11	3	7	6	7	9
1827	45,300	28,900	22,800	12	6	8	0	8	6
1828	30,000	31,000	31,100	10	0	6	3	6	6
1829	43,200	33,000	31,200	8	9	5	3	5	9
				Years.					
1830–1	32,100	32,800	37,600	1831 7	9	4	3	4	9
1831–2	32,500	34,500	35,700	1832 6	3	4	3	4	6
1832–3	35,200	35,500	32,500	1833 6	0	4	2	4	4
1833–4	27,100	34,600	35,800	1834 8	0	6	3	6	6
1834–5	30,500	33,800	29,319	1835 7	0	5	3	5	6
1835–6	32,600	34,700	21,449	1836 6	3	4	9	5	0
1836–7	–	32,600	26,219	1837 8	9	6	9	7	0

East India and Spanish, &c. Indigo.

Years.	Importations.		Exported.	Home Consumption.
	East India.	Spanish, &c.		
	lbs.	*lbs.*	*lbs.*	*lbs.*
1785	154,291	1,539,218	584,885	
1786	253,345	1,724,945	466,696	
1787	361,046	1,514,784	502,800	
1788	622,691	1,473,920	445,857	
1789	371,469	1,594,618	673,630	
1790	531,619	1,307,088	821,131	
1791	465,198	1,141,589	870,185	
1792	581,827	1,274,538	880,951	
1793	990,766	1,066,817	929,707	
1794	1,403,650	1,487,642	1,623,908	
1795	2,862,684	1,424,941	1,387,171	
1796	3,897,120	680,915	1,883,320	
1797	1,754,233	535,845	3,105,610	
1798	3,862,188	192,060	1,718,624	
1799	2,529,377	512,459	2,585,755	
1800	2,674,317	1,076,417	2,586,833	
1801	2,123,637	827,696	2,281,812	
1802	2,264,199	669,679	1,961,346	
1803	2,632,110	522,825	1,130,194	
1804	2,765,871	395,258	1,523,095	
1805	4,666,292	687,319	1,845,035	
1806	2,612,181	319,394	2,904,614	
1807	5,326,032	715,809	2,006,463	
1808	5,314,860	477,625	1,568,351	
1809	2,179,083	674,048	3,179,861	
1810	5,243,613	883,061	2,485,679	
1811	4,453,932	658,577	1,566,056	
1812	4,461,793	354,171	1,853,916	
1813	Accounts destroyed by Fire at Custom House.			
1814	6,803,064	328,881	5,501,851	3,406,282
1815	5,543,852	79,253	4,278,674	2,774,091
1816	7,247,227	39,275	4,214,454	1,899,819
1817	5,001,280	134,313	2,427,443	2,377,659
1818	5,497,768	187,257	2,963,462	2,302,163

EAST INDIA and SPANISH, &c. INDIGO.—*Continued.*

Years.	Importations.		Exported.	Home Consumption.
	East India.	Spanish, &c.		
1819	3,689,052	129,682	3,126,739	2,033,601
1820	4,924,222	161,164	4,378,857	2,288,196
1821	3,943,592	119,517	2,985,364	1,959,509
1822	2,549,284	374,230	2,378,948	2,004,062
1823	6,557,296	664,408	2,783,504	2,322,221
1824	4,595,707	485,110	2,795,740	2,493,350
1825	6,233,335	560,296	3,870,929	2,381,233
1826	7,699,439	386,312	4,365,163	1,901,047
1827	5,404,811	662,936	3,315,675	2,399,365
1828	9,683,626	229,384	4,588,658	3,064,915
1829	.5,978,527	769,757	4,286,605	2,113,830
1830	7,920,924	295,516	4,686,784	2,676,945
1831	7,004,510	290,089	4,374,241	2,490,134
1832	6,221,725	131,340	5,346,725	2,395,653
1833	6,304,016	331,016	3,664,814	2,323,300
1834	3,798,144	357,152	3,928,226	2,447,827
1835	3,986,233	183,480	4,074,598	2,606,772
1836	6,753,898	418,800	3,691,951	2,864,274
1837	5,872,601	673,270	3,587,561	2,240,451

NDIAN RUBBER is the vulgar name of caoutchouc in this country.

NK (*Encre*, Fr.; *Tinte*, Germ.) is a colored liquid for writing on paper, parchment, n, &c. with a pen.

llack ink.—Nutgalls, sulphate of iron, and gum, are the only substances truly useful he preparation of ordinary ink; the other things often added merely modify the shade, considerably diminish the cost to the manufacturer upon the great scale. Many of se inks contain little gallic acid, or tannin, and are therefore of inferior quality. To te 12 gallons of ink, we may take—

> 12 pounds of nutgalls,
> 5 pounds of green sulphate of iron,
> 5 pounds of gum senegal,
> 12 gallons of water.

The bruised nutgalls are to be put into a cylindrical copper, of a depth equal to its meter, and boiled, during three hours, with three fourths of the above quantity of ter, taking care to add fresh water to replace what is lost by evaporation. The oction is to be emptied into a tub, allowed to settle, and the clear liquor being wn off, the lees are to be drained. Some recommend the addition of a little bullock's od or white of egg, to remove a part of the tannin. But this abstraction tends to lessen product, and will seldom be practised by the manufacturer intent upon a large return his capital. The gum is to be dissolved in a small quantity of hot water, and the cilage thus formed, being filtered, is added to the clear decoction. The sulphate of a must likewise be separately dissolved, and well mixed with the above. The color kens by degrees, in consequence of the peroxydizement of the iron, on exposing the to the action of the air. But ink affords a more durable writing when used in the e state, because its particles are then finer, and penetrate the paper more intimately. ien ink consists chiefly of tannate of peroxyde of iron, however black, it is merely erficial, and is easily erased or effaced. Therefore, whenever the liquid made by the ve prescription has acquired a moderately deep tint, it should be drawn off clear into tles, and well corked up. Some ink-makers allow it to mould a little in the casks ore bottling, and suppose that it will thereby be not so liable to become mouldy in the tles. A few bruised cloves, or other aromatic perfume, added to ink, is said to pre- it the formation of mouldiness, which is produced by the ova of infusoria animalcules. refer digesting the galls to boiling them.

The operation may be abridged, by peroxydizing the copperas beforehand, by moderate eination in an open vessel; but, for the reasons above assigned, ink made with such a pbate of iron, however agreeable to the ignorant, when made to shine with gum and rar, under the name of japan ink, is neither the most durable nor the most pleasant to ite with.

From the comparatively high price of gall-nuts, sumach, logwood, and even

oak bark, are too frequently substituted, to a considerable degree, in the manufacture of ink.

The ink made by the prescription given above, is much more rich and powerful than many of the inks commonly sold. To bring it to their standard, a half more water may safely be added, or even 20 gallons of tolerable ink may be made from that weight of materials, as I have ascertained.

Sumach and logwood admit of only about one half of the copperas that galls will take to bring out the maximum amount of black dye.

Chaptal gives a prescription in his *Chimie appliquée aux arts*, which, like many other things in that book, are published with very little knowledge and discrimination. He uses logwood and sulphate of copper, in addition to the galls and sulphate of iron; a pernicious combination, productive of a spurious fugitive black, and a liquor corrosive of pens. It is, in fact, a modification of the vile dye of the hatters.

Lewis, who made exact experiments on inks, assigned the proportion of 3 parts of galls to 1 of sulphate of iron, which, with average galls, will answer very well; but good galls will admit of more copperas.

Gold ink is made by grinding upon a porphyry slab, with a muller, gold leaves along with white honey, till they be reduced to the finest possible division. The paste is then collected upon the edge of a knife or spatula, put into a large glass, and diffused through water. The gold by gravity soon falls to the bottom, while the honey dissolves in the water, which must be decanted off. The sediment is to be repeatedly washed till entirely freed from the honey. The powder, when· dried, is very brilliant, and when to be used as an ink, may be mixed up with a little gum water. After the writing becomes dry, it should be burnished with a wolf's tooth.

Silver ink is prepared in the same manner.

Indelible ink.—A very good ink, capable of resisting chlorine, oxalic acid, and ablution with a hair pencil or sponge, may be made by mixing some of the ink made by the preceding prescription, with a little genuine China ink. It writes well. Many other formulæ have been given for indelible inks, but they are all inferior in simplicity and usefulness to the one now prescribed. Solution of nitrate of silver thickened with gum, and written with upon linen or cotton cloth, previously imbued with a solution of soda, and dried, is the ordinary permanent ink of the shops. Before the cloths are washed, the writing should be exposed to the sun-beam, or to bright daylight, which blackens and fixes the oxyde of silver. It is easily discharged by chlorine and ammonia.

Red ink.—This ink may be made by infusing, for 3 or 4 days in weak vinegar, Brazil wood chipped into small pieces; the infusion may be then boiled upon the wood for an hour, strained, and thickened slightly with gum arabic and sugar. A little alum improves the color. A decoction of cochineal with a little water of ammonia, forms a more beautiful red ink, but it is fugitive. An extemporaneous red ink of the same kind may be made by dissolving carmine in weak water of ammonia, and adding a little mucilage.

Green ink.—According to Klaproth, a fine ink of this color may be prepared by boiling a mixture of two parts of verdigris in eight parts of water, with one of cream of tartar, till the total bulk be reduced one half. The solution must be then passed through a cloth, cooled, and bottled for use.

Yellow ink is made by dissolving 3 parts of alum in 100 of water, adding 25 parts of Persian or Avignon berries bruised, boiling the mixture for an hour, straining the liquor, and dissolving in it 4 parts of gum arabic. A solution of gamboge in water forms a convenient yellow ink.

By examining the different dye-stuffs, and considering the processes used in dyeing with them, a variety of colored inks may be made.

China ink.—Proust says, that lamp-black purified by potash ley, when mixed with a solution of glue, and dried, formed an ink which was preferred by artists to that of China. M. Merimée, in his interesting treatise, entitled, *De la peinture à l'huile*, says, that the Chinese do not use glue in the fabrication of their ink, but that they add vegetable juices, which render it more brilliant and more indelible upon paper. When the best lamp-black is levigated with the purest gelatine or solution of glue, it forms, no doubt, an ink of a good color, but wants the shining fracture, and is not so permanent on paper as good China ink; and it stiffens in cold weather into a tremulous jelly. Glue may be deprived of the gelatinizing property by boiling it for a long time, or subjecting it to a high heat in a Papin's digester; but as ammonia is apt to be generated in this way, M. Merimée recommends starch gum made by sulphuric acid (British gum) to be used in preference to glue. He gives, however, the following directions for preparing this ink with glue. Into a solution of glue he pours a concentrated solution of gall-nuts, which occasions an elastic resinous-looking precipitate. He washes this matter with hot water, and dissolves it in a spare solution of clarified glue. He filters

anew, and concentrates it to the proper degree for being incorporated with the purified lamp-black. The astringent principle in vegetables does not precipitate gelatine when its acid is saturated, as is done by boiling the nutgalls with limewater or magnesia. The first mode of making the ink is to be preferred. The lamp-black is said to be made in China, by collecting the smoke of the oil of sesame. A little camphor (about 2 per cent.) has been detected in the ink of China, and is supposed to improve it. Infusion of galls renders the ink permanent on paper.

Sympathetic ink. The best is a solution of muriate of cobalt.

Printer's ink. See this article.

By decomposing vanadate of ammonia with infusion of galls, a liquid is obtained of a perfectly black hue, which flows freely from the pen, is rendered blue by acids, is insoluble in dilute alkalis, and resists the action of chlorine. Whenever the metal vanadium shall become more abundant, as it probably may ere long, we shall possess the means of making an ink, at a moderate price, much superior to the tannate and gallate of iron.

To prepare the above vanadic salt cheaply, the cinder or hammerschlag obtained from the iron made at Ekersholm, in Sweden, or other iron which contains vanadium, being reduced to a fine powder, is to be mixed with two thirds of its weight of nitre, and one third of effloresced soda. The mixture is to be ignited in a crucible; cooled and lixiviated, whereby solutions of the vanadates of potash and soda are obtained, not pure, indeed, but sufficiently so for being decomposed, by means of sal ammoniac, into a vanadate of ammonia. This being rendered nearly neutral with any acid, constitutes an excellent indelible ink.

INULINE (Eng. and Fr.) is a substance first extracted from the root of the *Inula-Helenium*, or Elecampane. It is white and pulverulent like starch; and differs from this substance chiefly because its solution, when it cools, lets fall the inuline unchanged in powder, whereas starch remains dissolved in the cold, as a jelly or paste.

Inuline is obtained by boiling the root sliced in 3 or 4 times its weight of water, and setting the strained decoction aside till it cools, when the pulverulent inuline precipitates. It exists also in the roots of colchicum, and pellitory.

IODINE (*Iode*, Fr.; *Iod*, Germ.) is one of the archæal undecompounded chemical bodies, which was discovered accidentally in 1812 by M. Courtois, a manufacturer of saltpetre, in the mother-waters of that salt. Its affinities for other substances are so powerful as to prevent it from existing in an insulated state. It occurs combined with potassium and sodium in many mineral waters, such as the brine spring of Ashby-de-la-Zouche, and other strongly saline springs. This combination exists sparingly in sea-water, abundantly in many species of *fucus* or sea-weed, and in the kelp made from them; in sponges; in several marine *molluscæ*, such as the *doris*, the *venus*, oysters, &c.; in several polyparies and sea plants, as the *gorgonia*, the *zostera marina*, &c.; particularly in the mother-waters of the salt-works upon the Mediterranean sea; and it has been found in combination with silver, in some ores brought from the neighborhood of Mexico.

Iodine is most economically procured from the mother-water of kelp, as furnished by those manufacturers of soap in Scotland and elsewhere who employ this crude alkaline matter. By pouring an excess of sulphuric acid upon that liquid, and exposing the mixture to heat in a retort, iodine rises in *violet* vapors (whence its name), and condenses in the receiver into black, brilliant, soft, scaly crystals, resembling graphite or plumbago. An addition of the peroxyde of manganese to the above mixture, favors the production of iodine. Souberain has proposed as a means of extracting it in greater abundance from a given quantity of the said mother-waters, to transform the iodide of potash or soda, present, into an insoluble iodide of copper, by pouring into them solution of sulphate of copper, which precipitates first of all one half of the iodine. He then decants the supernatant liquor, and adds to it a fresh quantity of the sulphate along with some iron filings. The latter metal seizes the oxygen and sulphuric acid of the cupreous salt, sets the copper free, which then seizes the other half of the iodine. To separate this iodide from the remaining iron filings, he agitates the whole with water, and decants the liquor. The filings immediately subside, but the iodide of copper remains for some time in a state of suspension. This compound, separated by a filter cloth, is to be mixed with twice its weight of the black peroxyde of manganese, and as much sulphuric acid as will make the mixture into a paste; which mixture being introduced into a retort, and distilled, the iodine comes over in its characteristic violet vapors, which are condensed into the glistening black substance in the receiver.

Iodine is always solid at atmospheric temperatures, though it slowly flies off with a peculiar offensive penetrating odor somewhat like chlorine. Its specific gravity is 4·946 at the temperature of 58° Fahr. Its prime equivalent, according to Berzelius, is

63·283, one volume of hydrogen being 1·000; but 126·566, if two volumes of hydrogen be reckoned unity, as most British chemists estimate it, from the composition of water. It possesses in a high degree electro-negative properties, like oxygen and chlorine; and therefore makes its appearance at the positive pole, when its compounds are placed in the voltaic circuit. It stains the skin yellow; and if applied for some time to it, is apt to produce painful ulcerations.

Iodine melts only at about 390° Fahr.; but with the vapor of water it volatilizes at 212°. It has a great affinity for hydrogen, and constitutes by that union hydriodic acid; a compound resembling in some respects muriatic or hydrochloric acid. It also can be combined with oxygen, and forms thereby iodic acid. Its compounds with carbon, phosphorus, sulphur, chlorine, azote, and many metals, have not been applied to any manufacturing purpose, and therefore need not be described here.

The chief application of iodine in the arts, is for the detection of starch, which its watery solution, though containing only one part in 5000, does readily, by the production of a deep purple color; this vanishes by exposing the starch to the air for some time, or more quickly by heating it.

As a medicine, iodine and its compounds, such as the iodides of potassium and iron, are supposed to possess great powers in resolving glandular swellings. The periodide of mercury is a brilliant red pigment, but somewhat evanescent.

Chlorine, bromine, and iodine, are frequently associated; and it has hitherto been reckoned a difficult problem to separate them from one another. The following plan is proposed by Mr. Lövig.

Heat the mixture of the dried chloride and bromide (or chloride and iodide) while a current of chlorine is made to pass over it, till no more bromine is carried off by the chlorine. Receive the gases in a solution of potash; saturate this fluid mixture of the chloride of potassium, and the chlorate and bromate of potash with nitric acid, adding afterwards nitrate of silver. A mixture of bromate and chloride of silver will precipitate. Dry the precipitate, calcine it, and calculate the proportion of bromine from the volume of oxygen gas now disengaged. It would be preferable to digest in a vial, the precipitate while moist, along with water of baryta, which decomposes the bromate of silver without acting upon the chloride. The excess of baryta being thrown down by carbonic acid, and the liquid being evaporated, a bromate of baryta is obtained, which may be washed with alcohol of 0·840. The solution of bromate of baryta may also be neutralized by nitric acid, and the bromic acid may be precipitated by nitrate of silver. The same method is applicable to the separation of iodine from chlorine.

After throwing down the solution of the mixed salts by nitrate of silver, Berzelius digests the washed precipitate in a closed bottle of water of baryta; whence results bromate of baryta without any chloride of barium. On evaporating the liquor we obtain crystallized bromate of baryta, which may be freed from a small accidental quantity of chloride, by washing with alcohol at 0·840. By calcination we then obtain bromide of barium, which, being distilled with sulphuric acid and peroxyde of manganese, affords bromine.

IRIDIUM is a metal discovered by Descotils in 1803, as also by Tennant in 1804; and is so called because its different solutions exhibit all the colors of the rainbow. It occurs only in the ore of platinum, being found there in two states; 1. united to that metal, and 2. as alloy of osmium and iridium, in the form of small, insulated, hard grains. Iridium is the most refractory of all the metals; and appears as a gray metallic powder. It is not fused by the flame of the hydroxygen lamp.

IRON (*Fer*, Fr.; *Eisen*, Germ.) is a metal of a bluish-gray color, and a dull fibrous fracture, but it is capable of acquiring a brilliant surface by polishing. Its specific gravity is 7·78. It is the most tenacious of metals, and the hardest of all those which are malleable and ductile. It is singularly susceptible of the magnetic virtue, but in its pure state soon loses it. When rubbed it has a slight smell, and it imparts to the tongue a peculiar astringent taste, called chalybeate. In a moist atmosphere, iron speedily oxydizes, and becomes covered with a brown coating, called rust.

Every person knows the manifold uses of this truly precious metal; it is capable of being cast in moulds of any form; of being drawn out into wires of any desired strength or fineness; of being extended into plates or sheets; of being bent in every direction; of being sharpened, hardened, and softened at pleasure. Iron accommodates itself to all our wants, our desires, and even our caprices; it is equally serviceable to the arts, the sciences, to agriculture, and war; the same ore furnishes the sword, the ploughshare, the scythe, the pruning hook, the needle, the graver, the spring of a watch or of a carriage, the chisel, the chain, the anchor, the compass, the cannon, and the bomb. It is a medicine of much virtue, and the only metal friendly to the human frame.

The ores of iron are scattered over the crust of the globe with a beneficent profusion, proportioned to the utility of the metal; they are found under every latitude, and every

zone; in every mineral formation, and are disseminated in every soil. Considered in a purely mineralogical point of view, without reference to their importance for reduction, they may be reckoned to be 19 in number; namely, 1. native iron of three kinds: pure, nickeliferous, and steely; 2. arsenical iron; 3. yellow sulphuret of iron; 4. white sulphuret of iron; 5. magnetic sulphuret of iron; 6. black oxyde of iron, either the loadstone, or susceptible of magnetism, and titaniferous; 7. compact *fer oligiste*, specular iron ore, as of Elba, and scaly *fer oligiste*; 8. hematite, affording a red powder; 9. hematite or hydrate of iron, affording a yellow powder, of which there are several varieties; 10. pitchy iron ore; 11. siliceo-calcareous iron, or yenite; 12. sparry carbonate of iron, and the compact clay iron-stone of the coal formation; 13. phosphate of iron; 14. sulphate of iron, native copperas; 15. chromate of iron; 16. arseniate of iron; 17. muriate of iron; 18. oxalate of iron; 19. titanate of iron.

Among all these different species, ten are worked by the miner, either for the sake of the iron which they contain; for use in their native state; or for extracting some principles from them advantageous to the arts and manufactures; such are arsenical iron, sulphate of iron, sulphuret of iron, and chromate of iron.

1. *Native iron* A. Pure.—This species is very rare, and its existence was long matter of dispute; though it has been undoubtedly found not only in volcanic formations, but in veins properly so called. It is not entirely like our malleable iron; but is whiter, more ductile, more permanent or less oxydizable in the air, and somewhat less dense. Among the best attested examples of pure native iron is that observed by M. Schreber, in the mountain of Oulle near Grenoble. The metal was entangled in a vein running through gneiss, and appeared in ramifying stalactites, enveloped in fibrous brown-oxyde of iron mixed with quartz and clay.

B. *The native nickeliferous* or *meteoric iron* is very malleable, often cellular, but sometimes compact, and in parallel plates, which pass into rhomboids or octahedrons. It is naturally magnetic, and by its nickel is distinguishable from terrestrial native iron. Macquart, in describing the famous mass found at mount Kemir in Siberia, says that the iron is perfectly flexible, and fit for making small instruments at a moderate heat; but in too strong a fire, the metal becomes short, brittle, and falls into grains under the hammer. Meteoric iron is covered with a sort of varnish which preserves its surface from the rusting action of the air; but this preservative property does not extend to the interior. Chladni has given a list of masses of meteoric iron, which have been known to fall at different times from the atmosphere, and of many specimens which indicate their atmospheric origin, by their aspect and composition. A portion of the mass of meteoric iron found at Santa-Rosa near Santa-Fe-de-Bogota, was made into a sword and presented to Bolivar.

c. *Native steel-iron.*—This substance has all the characters of cast-steel; it occurs in a kind of small button ingots, with a finely striated surface, and a fracture exceedingly fine grained. It is hardly to be touched by the file, and will scarcely flatten under the hammer. M. Mossier found this native steel at the village of Bouiche, near Nery, department of the Allier, in a spot where there had existed a seam of burning coal. A mass of 16 pounds and 6 ounces of native steel was discovered in that place, besides a great many small globules.

2. *Arsenical iron*, *Arsenikkies*, or *Mispickel*, is a tin-white mineral, which emits a garlic smell at the blowpipe, or even when sparks are struck from it by steel, accompanied with a small train of white smoke. It contains generally more or less sulphur, and sometimes a little silver, associated with metallic arsenic and iron.

3. *Yellow sulphuret of iron*, commonly called *Marcasite*, or Martial pyrites. The bronze or brass yellow color enables us to recognise this mineral. At the blowpipe it gives off its sulphur, and is converted into a globule attractable by the blowpipe. It is a bisulphuret of iron containing 32 of sulphur and 28 of metal.

Copper pyrites may be distinguished from it by its golden yellow color, which is frequently iridescent, and by its inferior hardness; for it does not strike fire with steel, like the preceding persulphuret. There is no vein, stratum, or mass of metallic ore which does not contain some iron pyrites; and it is often the sole mineral that fills the veins in quartz. It sometimes contains gold, and at other times silver.

4. *White sulphuret of iron.*—This is distinguishable from the preceding species only by its color and form of crystallization, and was hence till lately confounded with it by mineralogists. Its surface is often radiated.

5. *Magnetic sulphuret of iron*, the *Magnetkies* of the Germans.—This ore is attractable by the magnet like common iron. Its color is reddish-yellow, passing into brown; its fracture is rough. It consists of 16 of sulphur and 28 of iron.

6. *Black oxyde of iron, magnet ore*, or *native loadstone.*—One variety of this species has two poles in each specimen, which manifest a repulsive action against the corresponding poles of a magnetic needle. All the varieties furnish a black powder. Its external color is a gray approaching to that of metallic iron, but somewhat duller;

with occasional iridescence of surface.   Neither nitric acid nor the blowpipe has any
action upon it.   Its specific gravity varies from 4·24 to 5·4; and its constituents are
71·86 peroxyde, and 28·14 protoxyde, according to Berzelius; or in 100 parts, 71·74 of
metallic iron, and 28·26 of oxygen.   Assuming the prime equivalent of iron to be 28,
with the British chemists, then an ore consisting, like the above, of two prime propor-
tions of peroxyde, and one of protoxyde, would be represented by the number 116 = 80
+ 36; and would consist in 100 parts, of iron 72·4, oxygen 27·6.

Magnetic iron-ore belongs to primitive rock formations, and occurs abundantly in
Sweden, Dalecarlia, Norway, Siberia, China, Siam, and the Philippine isles; but it is
rare in England and France.   It is worked extensively in Sweden, and furnishes an ex-
cellent iron.

The titaniferous oxyde of iron, or iron sand, is also attractable by the magnet.   Its
color is a deep.black, with some metallic lustre; it is perfectly opaque; its fracture is
conchoidal; it is hard and difficult to grind under the pestle into a dull black powder,
which stains the fingers when it is very fine; it melts at a high heat into a black enamel
without lustre.   All volcanic rocks contain a greater or less quantity of titanic iron-ore,
disseminated through them, which may be recognised by its brilliant metallic lustre, and
its perfect conchoidal fracture.

7. *Fer oligiste, iron-glance, specular iron, and red iron ore.*—This ore has the color of
polished steel; and the light transmitted through the thin edges of its crystals appears of
a beautiful red.   Its powder is always of a well marked brown-red hue, passing into
cherry-red, which distinguishes it from the black-oxyde ore.   Its fracture is rough, or
vitreous in certain varieties; it breaks easily; but it is hard enough to scratch glass.   It
usually contains from 60 to 70 of metallic iron in 100 parts; the equivalent proportion
of oxygen in the pure red oxyde of iron being 30 parts combined with 70 of metal.   It
is a mistake to suppose any specular iron ore capable of yielding 85 per cent. of iron, for
100 parts of even protoxyde of iron contain only 77·77 parts of metal.

The compact variety comprises the crystals of the island of Elba, and of Framont in
the Vosges, which have a rough-grained fracture.   It exists in very great masses, consti-
tuting even entire mountains; in the cavities and fissures of these masses, the beautiful
crystals so much prized by collectors of minerals, occur.

The island of Elba is equally celebrated for its inexhaustible abundance of rich specular
iron ore, and for the immemorial antiquity of its mining operations.   *Fig.* 581 is a vertical

581

section passing through the three workings, called Pietamonte (D), Sanguinaccio (s),
Antenna (F), through an ancient excavation a, through the coast o, and the mole p, end-
ing at the canal of Piombino.   The total height of the metalliferous mountain above the
level of the sea, is no more than 180 metres, or 600 feet.

The rock which constitutes the body of this little mountain d l, is called *bianchella* by
the workmen.   It is a white slaty talc, slightly ochreous, or yellowish, consisting chiefly
of silica and alumina, with some magnesia.   :

The ore of Antenna (F) is a very hard compact *fer oligiste*, of a brilliant metallic
aspect.   The workable bed has a height of 66 feet, and consists of metalliferous blocks
mixed confusedly with sterile masses of the rock; the whole covered with a rocky detri-
tus, under a brownish mould.   From its metallic appearance and toughness, this bed is
called *rena ferrata*, the iron vein.   In Pietamonte the workable bed is composed entirely
of micaceous specular iron ore (*fer oligiste*), with its fissures filled with yellow ochre.
This bed rests upon the rock called *bianchella;* the brilliant aspect of ore in this place
has gained for it the name of *rena lucciola.*

The metalliferous hill d l, extends to the north-east, about a mile beyond the work-
ings D E F.   The ore contains about 65 per cent. of iron, and is smelted in Catalan
forges.

The following description of the figure will make the structure of this extraordinary
mine well understood.   a, is a great excavation, the result of ancient workings.

1, 1; 2, 2; 3, 3, 4, 4, 5, 6, and 7, are roads for carrying off the rubbish, in correspond
once with the several working levels.

b, b, b, masses of old rubbish (*deblais*).

c, c, ditto, from the present workings D, E, F.

d, the rocky mass called bianchetta, against which the ore extracted from *a* abuts.

e, the surface of a bed of ore, near the streamlet *g.*

f, f, indication of beds of iron pyrites and *fer oligiste.*

g, a small rivulet proceeding from the infiltration of rains, and which is impregnated with acidulous sulphate of iron.

h, h, ravine which separates the metalliferous hill *d l* from the barren hill *i.*

k, masses of slags from ancient smelting operations; such are very common in this island. None of any consequence now exist; nearly the whole of the ore being exported to Tuscany, the Romagna, the Genoese territories, Piedmont, Naples, and Corsica.

l, a considerable body of rubbish from ancient workings, towards the summit of the metalliferous hill *d, l.*

m, m, part of this hill covered with rubbish, the result of old workings.

n, the site called *Vigneria.*

o, houses upon the shore called *Marine de Rio,* where the workpeople live, and the mineral is kept in store.

p, wooden pier (*mole*) whence the ore is shipped; terminated by a small tower, *q.*

Compact *fer oligiste* occurs also in the Vosges, in Corsica, at Altenberg and Freyburg, in Saxony, Presnitz, in Bohemia, Norberg and Bisberg, in Sweden, &c.

The varieties called specular *fer oligiste,* and scaly *fer oligiste,* or iron-glance, do not differ essentially from the compact. None of them affects the magnetic needle, and their powder is a red of greater or less vivacity.

8. *Red oxyde of iron.*—The varieties included under this species afford a red powder, do not affect the magnetic needle, and are destitute of metallic lustre. At the blowpipe they all become black, or deep brown; and then they act on the needle. The crystallized variety consists of 70 iron and 30 oxygen in 100 parts. The concretionary kind, or *hematite,* has a brown-red color; is solid, compact, and sometimes very hard; its surface may be filed and polished so as to acquire a lustre almost metallic; its internal structure is fibrous, and it exhibits sometimes a resemblance to splinters of wood. Its outer surface is constantly concretionary, mammelated, and presents occasionally sections of a sphere, or cylinders attached to each other. This is the blood-stone of the burnisher of metals. It is a very common mineral. The ochry variety or red-iron-ochre is distinguished from the solid hematite by the brightness of its color. It is used as a pigment.

9. *Brown oxyde of iron, brown iron-stone.*—This affords always a yellow powder, without any shade of red, which passes sometimes into the bistre brown, or velvet black. At the blowpipe this oxyde becomes brown, and very attractable by the magnet; but after calcination and cooling, the ore yields a red powder, which stains paper nearly as red as hematite does, and which is much employed in polishing metals. All the yellow or brown oxydes contain a large proportion of water, in chemical combination; and hence this species has been called hydrate of iron. There are several varieties which assume globular, reniform, stalactitic, and fruticose shapes. As impure varieties of the species we must consider some of the clay-iron ores, such as the granular, the common, the pisiform, and the reniform clay-iron ore. According to D'Aubuisson, the present species consists of peroxyde of iron, from 82 to 84 *per cent.;* water, 14 to 11; oxyde of manganese, 2; silica, 1 to 2. It is therefore a hydrated peroxyde of iron; and ought by theory to consist, in its absolute state, of 81·63 peroxyde, and 18·37 water. It occurs both in beds and veins. The *ætites* or eagle-stones form a particular variety of this ore. On breaking the balls, so named, they are observed to be composed of concentric coats, the outside ones being very hard, but the interior becoming progressively softer towards the centre, which is usually earthy and of a bright yellow color; sometimes, however, the centre is quite empty, or contains only a few drops of water. Œtites occur in abundance, often even in continuous beds in secondary mountains, and in certain argillaceous strata. These stones are still considered by the French shepherds as amulets or talismans, and may be found in the small bags which they suspend to the necks of their favorite rams; and they are in such general use, that a large quantity is annually imported into France from the frontiers of Germany, for this superstitious purpose. When smelted, they yield a good iron.

The variety called *granular brown oxyde,* or *bone ore,* is merely a modification of the preceding. It occurs in grains nearly round, varying in size from a millet seed to a pea, each being composed of concentric coats, hard outside and soft within. They are generally agglutinated by a calcareous or argillaceous paste; but are occasionally quite loose. This ore occurs in calcareous formations, and is sometimes accompanied with shells, such as *terebratulæ.* The brittle quality of the iron afforded by it has been ascribed to the phosphorus derived from the large quantity of organic bodies, with

which the ore is frequently mixed. The bog-iron ore and swamp-iron ore belong to this species.

10. *Pitchy hydrate of iron.*—This is a rare mineral of a resinous aspect, found in a vein in the mine of Braunsdorf, two leagues from Freyberg, and seems to consist of red oxyde of iron and water.

11. *Yenite* is a mineral species, rather rare, composed of red oxyde of iron, silica, and lime.

12. *Carbonate of iron, sparry iron, or brown-spar.*—This important species has been divided into two varieties; spathose iron and the compact carbonate. The first has a sparry and lamellar fracture; with a color varying from yellowish-gray to isabella yellow, or even to brownish-red. It turns brown without melting at the blowpipe, and becomes attractable by the magnet after being slightly roasted in the flame of a candle. Even by a short exposure to the air, after its extraction from the mine, it also assumes the same brown tint, but without acquiring the magnetic quality. It affords but a slight effervescence with nitric acid, changing merely to a red-brown color. Its specific gravity varies from 3·00 to 3·67. Its primitive form is like that of carbonate of lime, an obtuse rhomboid. Without changing this form, its crystals are susceptible of containing variable quantities of carbonate of lime, till it passes wholly into this mineral. Manganese and magnesia enter also occasionally into its composition.

Sparry carbonate of iron belongs to primitive formations; forming powerful veins in mountains of gneiss, and is associated in these veins with quartz, copper pyrites, gray copper, fibrous brown oxyde of iron, and a variety of ramose carbonate of lime, vulgarly called *flos ferri*. Thus it is found at Allevard and Vizille, near Grenoble, at Saint-George d'Huretière, in the Alps of Savoy; at Baigorry, in the Lower Pyrenees; at Eisenerz, in Styria; at Huttenberg, in Carinthia; at Schwartz, in the Tyrol; in Saxony, Hungary, other places in Germany, as also in Spain, Sweden, Norway, and Siberia. It also occurs, along with galena and other ores of lead, in the mines of Lead-Hills and Wanlockhead, in Scotland; and in the mines of Cumberland, Northumberland, and Derbyshire; likewise with tin-ore, at Wheal Maudlin, Saint-Just, and other places in Cornwall.

This ore, viewed as a metallurgic object, is one of the most interesting and valuable that is known; it affords natural steel with the greatest facility, and accommodates itself best to the Catalan smelting forge. It was owing in a great measure to the peculiar quality of the iron which it produces, that the excellence long remarked in the cutlery of the Tyrol, Styria, and Carinthia, was due. It was called by the older mineralogists *steel ore.*

The carbonate of iron of the coal formation, is the principal ore from which iron is smelted in England and Scotland, and it yields usually from 30 to 33 per cent. of cast metal. We are indebted to Dr. Colquhoun for several elaborate analyses of the sparry-irons of the Glasgow coal field; ores which afford the best qualities of iron made in that district. The richest specimen, out of the nine which he tried, came from the neighborhood of Airdrie; it had a specific gravity of 3·0533, and afforded in 100 parts, carbonic acid, 35·17; protoxyde of iron, 53·03; lime, 3·33; magnesia, 1·77; silica, 1·4; alumina, 0·63; peroxyde of iron, 0·23; carbonaceous or bituminous matter, 3·03; moisture and loss, 1·41. Its contents in metallic iron are 41·25.

The *compact carbonate of iron* has no relation externally with the sparry variety. It comprehends most of the clay-iron stones, and particularly that which occurs in flattened spheroidal masses of various size, among the coal measures. The color of this ore is often a yellowish-brown, reddish-gray, or a dirty brick-red. Its fracture is close grained; it is easily scratched, and gives a yellowish-brown powder. It adheres to the tongue, has an odor slightly argillaceous when breathed upon, makes no effervescence with any acid, blackens at the blow-pipe without melting, and becomes attractable by the magnet with the slightest calcination.

This ore affords from 30 to 40 per cent. of iron of excellent quality; and it is the object of most extensive workings in Great Britain. It occurs in the slaty clay which serves as a roof or floor to the strata of coal; and also in continuous beds, from 2 to 18 inches thick, among the coal measures, as in Staffordshire, Shropshire, and Wales. It is remarkable, that the coal-basin of Newcastle contains little clay iron-stone, while the coal-basin of Dudley is replete with it.

13. *Phosphate of iron.*—A dull blue color is the most remarkable external character of this species, which occurs in small masses composed of aggregated plates, sometimes in an excessively fine powder, or giving other bodies a blue tinge. It assumes at the blowpipe a rusty hue, and is then reduced to a button of a metallic aspect. It dissolves completely in dilute nitric acid, as well as in ammonia, but it does not communicate its color to them, and oil turns it black; characters which distinguish it readily from blue carbonate of copper, whose color is not altered by ammonia. It is of no use as a smelting ore.

14. *Sulphate of iron, native green vitriol.*—This is formed by the oxygenation of sulphuret of iron, and is unimportant in a metallurgic point of view.

15. *Chromate of iron.*—For the treatment and use of this ore, see CHROME.

16. *Arseniate of iron, Wurfelerz.*

17. *Muriate of iron.*

18. *Oxalate of iron; Humboldtile*, found by M. Breithaupt in the lignite of Kolaw. It consists of protoxide of iron, 53·86; oxalic acid, 46·14; in 100.

19. *Titanate of iron* consists of protoxyde and peroxyde of iron, 86; titanic acid, 8; oxyde of manganese, 2; gangue, 1 = 97. See *Black Oxyde* of iron.

Of the assay of iron-ores by fusion.—In the assays by the dry way, the object is to separate exactly all the iron which the ore may contain, with the view of comparing the result with the product of smelting on the great scale. In order to succeed in this operation, we must deoxydize the iron, and produce at the same time such a temperature as will melt the metal and the earths associated with it in the ore, and obtain the former in a dense button at the bottom of a crucible, and the latter in a lighter glass or slag, above it. Sometimes the gangue of the ores, consisting mostly of a single earth, as quartz, alumina, or lime, is of itself very refractory, and hence some flux must be added to bring about the fusion. The substance most commonly employed for this purpose is borax; but ordinary flint glass may be substituted for it. Sometimes, also, instead of adding borax, which always succeeds, lime or clay may be added to the ore, according to the nature of its mineralizer; that is, lime for a clay iron-stone, and clay for a calcareous carbonate of iron; and both, when the gangue is silicious, as occurs with the black oxyde.

The ore, pulverized and passed through a silk sieve, is to be well mixed with the flux, and the mixture introduced into the smooth concavity made in the centre of a crucible lined with hard-rammed damp charcoal dust. Were the mixture diffused through the charcoal, the reduced iron would be apt to remain scattered in little globules through the crucible, and no metallic button would be formed at its bottom. The mingled ore and flux must be covered with charcoal. The crucible thus filled must be shut with an earthen lid luted on with fire-clay; and it is then set on its base, either in an air furnace, or on the hearth of a forge urged with a smith's bellows. The heat should be very slowly raised, not employing the bellows till three quarters of an hour have expired. In this way, the water of the damp charcoal (*brasque*) is allowed to exhale slowly, and the deoxydation is completed before the fusion begins; for by acting otherwise, the slags formed would dissolve some oxyde of iron, and the assay would not indicate the whole of the iron to be obtained from the ore. At the end of the above period, the fire must be raised progressively to a white heat, at which pitch it must be maintained for a quarter of an hour, after which the crucible should be withdrawn. Whenever it has cooled, it is to be opened, the *brasque* must be carefully removed or put aside, and the button of cast-iron taken out and weighed. The *brasque* may sometimes contain a few globules, which must be collected by washing in water, or the application of a magnetic bar. The quantity of iron denotes, of course, the richness of the ore. These assays furnish always a gray cast-iron; and, therefore, the quality of the products can hardly be judged of, except by an experiment on the large scale. The temperature necessary for the success of an assay is about 150° of Wedgewood.

In the assays by the *humid* way, we may expect to find manganese, silica, alumina, lime, magnesia, and sometimes carbonic acid, associated with the iron. 100 grains of the ore in fine powder are to be digested with nitro-muriatic-acid; which will leave only the silica with perhaps a very little alumina. If an effervescence takes place in the cold with a dilute acid, the loss of weight will indicate the amount of carbonic acid gas expelled. The muriatic solution contains the iron, the manganese, the lime, magnesia, and most of the alumina, with a little silica. On evaporating to dryness, and digesting in water, all the silica will remain in an insoluble state. If the solution somewhat acidulated be treated with oxalate of ammonia, the lime will fall down in the form of an oxalate; ammonia will now precipitate the alumina and the oxyde of iron together, while the manganese and magnesia will continue dissolved in the state of triple salts (ammonia-muriates). The alumina may be separated from the ferric oxyde by potash-ley. The manganese may be thrown down by hydrosulphuret of potash; and, finally, the magnesia may be precipitated by carbonate of soda. 100 parts of the red oxyde of iron contain 69·34 of metal, and 30·66 of oxygen.

If phosphorus be present in the ore, the nitro-muriatic solution, being rendered nearly neutral, will afford with muriate of lime a precipitate of phosphate of lime, soluble in an excess of muriatic acid.

When the sole object is to learn readily the per-centage of iron, the ore may be treated with hot nitro-muriatic, the acid solution filtered and supersaturated with ammonia, which will throw down only the iron oxyde and alumina; because the lime is not precipitable by that alkali, nor is magnesia and manganese, when in the state of ammonia-

muriates. The red precipitate, being digested with some potash-ley, will lose its alumina, and will leave the ferric oxyde nearly pure. The presence of sulphur, phosphorus, or arsenic, in iron ores, may always be detected by the blowpipe, or ustulation in the assay muffle, as described under FURNACE.

Of the smelting of iron ores.—We shall describe, in the first place, the methods practised in Great Britain, and shall afterwards consider those pursued in other countries, in the treatment of their peculiar ores.

Iron is divided into three kinds, according to the different metallic states in which it may be obtained ; and these are called *crude* or *cast iron ; steel ;* and *bar* or malleable iron. These states are determined essentially by the different proportions of charcoal or carbon held in chemical combination ; cast iron containing more than steel, and steel more than malleable iron ; which last, indeed, ought to be the pure metal, a point of perfection, however, rarely if ever attained. It is impossible to assign the limits between these three forms of iron, or their relative proportions of carbon, with ultimate precision ; for bar iron passes into steel by insensible gradations, and steel and cast iron make such mutual transitions as to render it difficult to define where the former commences, and the latter ceases, to exist. In fact, some steels may be called crude iron, and some cast irons may be reckoned among steels.

Towards the conclusion of the last century the manufacture of iron underwent a very important revolution in Great Britain, by the substitution of pitcoal for charcoal of wood, the only combustible previously used in smelting the ores of this metal. This improvement served not merely to diminish the cost of reduction, but it furnished a softer cast iron, fit for many new purposes in the arts. From this era, iron works have assumed an immense importance in our national industry, and have given birth to many ingenious and powerful machines for fashioning the metal into bars of every form, with almost incredible economy and expedition.

The profusion of excellent coal, and its association in many localities with iron-stone, have procured hitherto for our country a marked superiority over all others in the iron trade ; though now every possible effort is making by foreign policy to rival or to limit our future operations. In 1802, M. de Bonnard, now divisionary inspector in the royal corps of mines of France, and secretary of the general council, made a tour in England, in order to study our new processes of manufacturing iron, and published, on his return, in the Journal des Mines, tom. 17, a memoir descriptive of them. Since the peace, many French engineers and iron-masters have exerted themselves in naturalizing in France this species of industry ; and M. de Gallois, in particular, after a long residence in Great Britain, where he was admitted to see deliberately and minutely every department of the iron trade, returned with ample details, and erected at Saint-Etienne a large establishment entirely on the English model. More recently, MM. Dufrénoy and Elie de Beaumont, and MM. Coste and Perdonnet, have published two very copious accounts of their respective metallurgic tours in Great Britain, illustrated with plans and sections of our furnaces, for the instruction of the French nation.

The argillaceous carbonate of iron, or clay iron-stone of the coal measures, is the chief ore smelted in England. Some red hematite is used as an auxiliary in certain works in Cumberland and Lancashire ; but nowhere is the iron-sand, or other ferruginous matters of the secondary strata, employed at present for procuring the metal.

Among the numerous coal-basins of England there are two, in particular, which furnish more than three fourths of the whole cast iron produced in the kingdom ; namely, the coal field of Dudley, in the south of Staffordshire ; and the coal fields of Monmouthshire, in South Wales, along with those of Gloucestershire and Somersetshire.

Dudley is peculiarly favored by nature. There are found associated the coal, the iron ore, the limestone for flux, and the refractory fire-clay for constructing the interior brick-work of the furnaces. This famous clay is mined at Stourbridge, and exported to every part of the kingdom for making cast steel crucibles and glass-house melting pots.

At Merthyr-Tydvil, the centre of the iron-works of Wales, the iron-stone is extremely plentiful, forming 16 beds, or rather constituting an integrant portion of 16 beds of slate-clay. Sometimes it occurs in pretty long tables adjoining each other, so as to resemble a continuous stratum ; but more frequently it forms nodules of various size and abundance, placed in planes both above and below the coal seam. Eight varieties of ore, belonging to different beds, have been distinguished by the following barbarous names : black balls, black pins, six-inch-wide vein, six-inch jack, blue vein, blue pins, gray pins, seven pins. The bed containing the first quality of iron-stone is analogous to the black ore of Staffordshire, called *gubbin ;* it is often cleft within like *septaria,* and its cavities are sometimes besprinkled with crystals of carbonate of lime or quartz. In the superior beds there are nodules decomposing into concentric coats, of which the middle is clay. Crystals of oxyde of titanium are occasionally found in the middle of

the balls of clay iron-stone; to which the metallic titanium observed in the inside of the dome of blast furnaces, may be traced. Both at Dudley and South Wales, casts of shells, belonging to the genus *unio*, are observed on the iron-stone.

The average richness of the iron-stones of South Wales is somewhat greater than that of those of Staffordshire. The former is estimated at 33 parts of cast iron, while the latter rarely exceeds 30 parts in 100 of ore; and this richness, joined to the superior quality or cheapness of the coals, and the proximity of the sea, gives South Wales a decided advantage as a manufacturing district.

The number of blast furnaces in the parish of Merthyr-Tydvil amounts to upwards of 30. The cast iron produced is, however, seldom brought into the market, but is almost entirely converted into bar iron, of which, at Mr. Crawshay's works, 600 tons are manufactured in a week. Numerous iron railways, extending through a length of 220 miles, facilitate the transport of the materials and the exportation of the products. That concurrence of favorable circumstances, which we have noticed as occurring at Dudley, prevails in an equal degree in South Wales.

The same economy which the use of coal has introduced into the smelting of cast iron from the ore, also extends to its refinery into bars. And this process would supersede in every iron work the use of wood charcoal, were not the iron produced by the latter combustible better for many purposes, particularly the manufacture of steel. In some English smelting works, indeed, where sheet iron is prepared for making tin plate, a mixed refining process is employed, where the cast iron is made into bar iron by wood charcoal, and laminated by the aid of a coal fire.

Till 1740, the smelting of iron ores in England was executed entirely with wood charcoal; and the ores employed were principally brown and red hematites. Earthy iron ores were also smelted; but it does not appear that the clay iron-stones of the coal-basins were then used, though they constitute almost the sole smelting material at the present day. At that era, there were 59 blast furnaces, whose annual product was 17,350 tons of cast iron; that is, for each furnace, 294 tons per annum, and 5¼ tons per week. By the year 1788, several attempts had been made to reduce iron ore with coked coal; and there remained only 24 charcoal blast furnaces, which produced altogether 13,000 tons of cast iron in the year; being at the rate of 546 tons for each per annum, or nearly 11 tons per week. This remarkable increase of 11 tons for 5¼, was due chiefly to the substitution of cylinder blowing machines worked with pistons, for the common wooden bellows. Already 53 blast furnaces fired with coke were in activity; which furnished in *toto* 48,800 tons of iron in a year; which raises the annual product of each furnace to 907 tons, and the weekly product to about 17½ tons. The quantity of cast iron produced that year (1788) by means of coal, was - - - - - - 48,800 tons, and that by wood charcoal, was - - - - - - 13,100

Constituting a total quantity of - - - - - - 61,900 tons.

In 1796, the wood charcoal process was almost entirely given up; when the returns of the iron trade made by desire of Mr. Pitt, for establishing taxes on the manufacture, afforded the following results:—

121 blast furnaces, furnishing in whole per annum 124,879 tons, constituting an average amount for each furnace of 1032 tons.

In 1802, Great Britain possessed 168 blast furnaces, yielding a product of about 170,000 tons; and this product amounted, in 1806, to 250,000 tons, derived from 227 coke furnaces, of which only 159 were in activity at once. These blast furnaces were distributed as follows.

In the principality of Wales - - - - - - - -	52
In Staffordshire - - - - - - - - - -	42
In Shropshire - - - - - - - - - - -	42
In Derbyshire - - - - - - - - - - -	17
In Yorkshire - - - - - - - - - - -	28
In the counties of Gloucester, Monmouth, Leicester, Lancaster, Cumberland, and Northumberland - - - - - - - -	18
In Scotland - - - - - - - - - -	28
	227

In 1820, the iron trade had risen to the amount shown in the following table:—

	Tons.
Wales manufactured, per annum - - - - - - -	150,000
Shropshire and Staffordshire - - - - - -	180,000
Yorkshire and Derbyshire - - - - - - -	50,000
Scotland, with some places in England - - - - -	20,000
Total - - - - - -	400 000

In a statistical view given by M. de Villefosse, of the French and English iron works he assigns to the latter, in 1826, 305 blast furnaces, distributed as follows :—

In the principality of Wales - - - - - - - -	87 .
In Staffordshire - - - - - - - - - -	78
In Shropshire, Derbyshire, Yorkshire, &c. - - - - - -	84
In Scotland - - - - - . - - - - -	56
	305

Out of these, 280 were in activity at the same time; and if we suppose their mean product to have been 50 tons a week, the total product would have been, in 1826, 728,000 tons. But this estimate seems to be somewhat above the truth; for, from the information communicated by Mr. Philip Taylor to M. Achille Chaper, a considerable French iron-master, who, in the summer of 1826, inspected two thirds of the blast furnaces of Great Britain, their product during this year was about 600,000 tons.

The preceding details show the successive increments which the manufacture of cast iron has received; and a similar progression has taken place in its refinery into wrought iron. This operation was formerly effected by the agency of wood charcoal in refineries analogous to those still made use of in France. But when that kind of fuel began to be scarce in this island, it came to be mixed with coke in various proportions. The bar iron thus produced was usually hard, and required much time to convert, so that an establishment which could produce 20 tons of bar iron in a week, was deemed considerable. At that time, England imported annually from Sweden and Russia the enormous quantity of 70,000 tons of iron.

Mr. Cort, to whom Great Britain is indebted for the methods now pursued in this country, succeeded about that time, after many unsuccessful experiments, in converting cast iron into bar iron, by exposing it on the hearth of a reverberatory furnace to the flame of pitcoal. This method, which possessed the advantage of employing this species of combustible alone, likewise simplified the treatment, because it required no blast apparatus. But this mode of refinery, consisting in the use of a reverberatory furnace alone, did not produce altogether the desired result. It was irregular; sometimes the loss of iron was small, but at others it was very considerable; and there were great variations in the quality of the iron, as well as in the quantity of fuel consumed. Mr. Cort succeeded in removing this uncertainty of result, by causing the puddling in the reverberatory furnace to be preceded by a kind of refinery with coke. The intent of this operation was to de-carburate the iron, and to prepare it for becoming malleable. The metal took in that case the name of *finery* metal, called, for the sake of brevity, *fine-metal*.

He also substituted the drawing cylinders for the extension under the hammer, an improvement which accelerated greatly the manufacture of bar iron. The iron then yielded by the operation of puddling was of a very inferior quality, and could not be directly employed in the arts. In order to give it more consistence, it was subjected to a second heating in a reverberatory furnace; and whenever this method had arrived at a high enough degree of perfection to afford products fit for the market, it became exclusively employed in Great Britain. This new method of transforming cast iron into malleable iron speedily gained such an extension, that of late years, a single iron-work, Cyfartha in Wales, manufactured annually more than twice as much as was made annually from 1740 to 1750, in the whole kingdom.

In surveying the improvements which the iron manufacture has received in England in the space of the last 60 years, they are seen to be resolvable into two; the first set relating to the smelting of the ores; the other, to the conversion of the pigs into bar iron; hence naturally arise two heads under which the subject of iron must be treated.

1. *Manufacture of cast-iron by coke and coal.*—The cast-iron produced by the English and Scotch blast furnaces is in general black and very soft; but yet may be distinguished into several qualities, of which three are particularly noticed.

No. 1. *Very black cast-iron*, in large rounded grains, obtained commonly near the commencement of the casting, when an excess of carbon is present; in flowing, it appears pasty, and throws out blue scintillations. It exhibits a surface where crystalline vegetations develop themselves rapidly in very fine branches; it congeals or fixes very slowly; its surface when cold is smooth, concave, and often charged with plumbago; it has but a moderate tenacity, is tender under the file, and susceptible of a dull polish. When melted over again, it passes into No. 2, and forms the best castings.

No. 2. *Black cast-iron* has a somewhat lighter shade than the preceding, and may therefore on comparison be called blackish-gray. It presents less large granulations than No. 1; is tenacious, easily turned, filed, and polished; excellent for casting when it approaches to No. 1, and for the manufacture of bar iron when it has on the contrary a shade somewhat lighter. If repeatedly melted, it passes into the next quality, or

No. 3. *White cast iron;* this is brittle, and indicates always some derangement in the

working of the furnace; it flows imperfectly, and darts out, in casting, abundance of brilliant white scintillations; it fixes very quickly; and on cooling, exhibits on its surface irregular asperities, which make it extremely rough. It is easily broken, and presents a lamellar and radiated fracture; and is so hard that tempered steel cannot act upon it. It is cast only into weights, bullets, or bombs, but never into pieces of machinery. When exposed to the refinery piocesses, it affords a bad bar iron. It is owing probably to the different nature of the cast iron obtained in different counties in England, that Stafford-shire and Shropshire furnish the greater part of the great iron castings, while Wales manufactures almost exclusively malleable iron. The lower price of coals in Wales is perhaps the cause to a certain extent of this difference in the results of these two iron districts. It will be interesting, at any rate, to describe separately the processes employed in Staffordshire and Wales.

The blast furnaces of Staffordshire, in the neighborhood of Dudley, Bilston, and Wednesbury, are constructed almost wholly of bricks. Their outer form is frequently a cone, often also a pyramid with a square base. They are bound about with a great many iron hoops, or with iron bars placed at different heights. This powerful armor allows the furnaces to be built much less massively than they formerly were; and admits lighter and more elegant external forms. They are seldom insulated; but are usually associated to the number of two or three in the same line. A narrow passage is left between them, which leads to the lateral openings where the tuyères are placed. At the
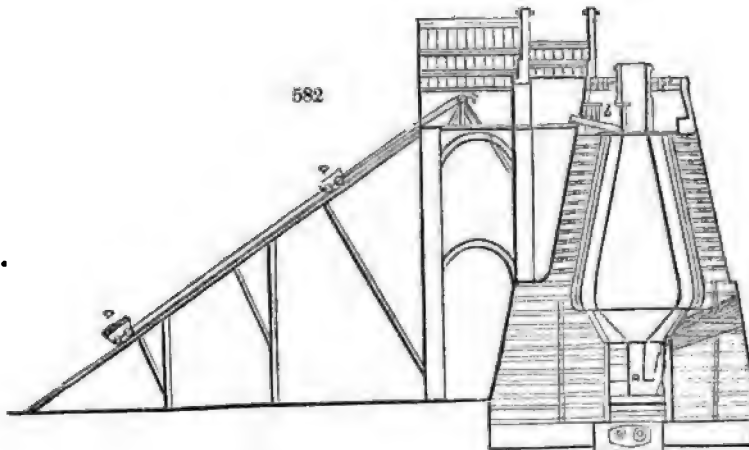
front of the furnace, a large shed is always raised. The roofs of these sheds present in general circular profiles, and being made of cast or bar iron, they display a remarkable lightness of construction. The cast iron columns likewise, which support the joists and girders, give additional elegance.

In the Dudley field, the furnaces are almost always in the middle of the plain, and an inclined rail-way must be formed to reach their platform. These inclined planes, com-posed of beams or rails placed alongside of each other, and sustained by props and cross-bars, as indicated in *fig*. 582, are set up mostly against the posterior face of the furnace. Two chains or ropes, passing over the drums of gins, moved by a steam engine (commonly the same that drives the bellows), draw up the wagons of wood or sheet iron *a a*, which contain the various materials for supplying the furnace. To facilitate this service, the platform round the furnace is sometimes enlarged behind by a floor; while a balustrade, which opens when the wagons arrive at the platform, prevents accidents. This pro-jection is occasionally covered by a roof. For a furnace of the largest size, the force ex-pended by this lifting apparatus is not more than a two-horse power.

Fig. 582 is a vertical section through the furnace from front to rear, or at right angles to the line of the lateral tuyères. The erection of a pair of blast furnaces, of 40 feet high each, costs, in the Dudley district, 1800 pounds sterling; and requires for building each, 160,000 common bricks for the outside work, 3900 fire-bricks for the lining or shirt of the furnace, and 825 for the boshes. The dimensions of the fire-bricks are various; 5 kinds are employed for the lining, and 9 kinds for the boshes. They are all 6 inches thick, and are curved to suit the *voussoirs*.

The number of charges given in 12 hours is different in different furnaces; being sometimes 20, 25, and even so high as 40; but 30 is a fair average. Each charge is

composed of from 5 to 6 cwts. of coke, (or now of 3 to 4 cwts. of coal with the hot blast); 3, 4, and sometimes 6 cwts. of the roasted mine, according to its richness and the quality of cast iron wanted; the limestone flux is usually one third of the weight of the roasted iron stone.   There are 2 casts in 24 hours; one at 6 in the morning, and another at 6 in the evening.

The height of the blast furnaces is very variable; some being only 36 feet high including the chimney, while others have an elevation of 60 feet.   These extreme limits are very rare: so that the greater part of the furnaces are from 45 to 50 feet high. They are all terminated by a cylindrical chimney of from 8 to 12 feet long; being about one fifth of the total height of the furnace.   The inside diameter of this chimney is the same as that of the throat or mouth; and varies from 4 to 6 feet.   The chimney is frequently formed of a single course of bricks, and acquires solidity from its hoops of iron, so thickly placed that one half of the surface is often covered with them.   At its lower end, the mouth presents one or two rectangular openings, through which the charge is given.   It is built on a basement circle of cast-iron, which forms the circumference of the throat; and a sloping plate of cast-iron *b* is so placed as to make the materials slide over into the furnace, as shown in the figure.

The inside of the blast furnaces of Staffordshire is most frequently of a circular form, except the hearth and working area.   The inner space is divided into four portions, different in their forms, and the functions which they fulfil in the smelting of the ore.

The undermost, called the hearth, or crucible, in which the cast-iron collects, is a right rectangular prism, elongated in a line prependicular to the axes of the tuyères.   The sides of the hearth consist in general of refractory sandstone (fire-stone), obtained mostly from the bed of the coal basin, called *millstone grit*; and the bottom of the hearth is formed of a large block of the same nature, laid on a cast-iron plate.

The second portion is also made of the same refractory grit stone.   It has the form of a quadrangular pyramidal, approaching considerably to a prism, from the smallness of the angle included between the sides and the axis.

The third portion or lower body of the furnace is conical, but here the interior space suddenly expands; the slope outwards at this part seems to have a great influence on the quality of the cast-iron obtained from the furnace.   When No. 2 of the blackest kind is wanted for castings, the inclination of this cavity of the furnace is in general less considerable than when No. 2 cast iron for conversion into bar iron is required.   The inclination of this conical chamber, called the boshes, varies from 55 to 60 degrees with the horizon.   The diameter of this part is equal to that of the belly, and is from 11 to 13 feet. The boshes are built of masonry, as shown in *figs.* 583, 584.

583

The fourth part, which constitutes about two thirds of the height of the furnace from the base of the hearth up to the throat, presents the figure of a surface of revolution, generated by a curve whose concavity is turned towards the axis of the furnace, and whose last tangent towards the bottom is almost vertical.   This surface is sloped off with that of the boshes (*étalages* in French), so that no sharp angle may exist at the belly. In some furnaces of considerable dimensions, as in that with three tuyères, this portion of the furnace is cylindrical for a certain height.

e following measurements represent the interior structure of two well-going ces.

	No. 1.	No. 2.
	Feet.	*Feet.*
ght from the hearth to the throat or mouth - -	45	49
ght of the crucible or hearth - - -	6½	6
— of the boshes - - - - -	8	7
— of the cone - - - - -	30¼	36
— of the chimney or mouth - - -	8	12¾
lth of the bottom of the hearth - - -	2½	2
to at its upper end - - - - -	3	2⅞
to of the boshes - - - - -	12¾	13½
to at one third of the belly - - - -	12	11½
to at two thirds of ditto - - - -	8¾	9½
to at the mouth - - - - -	4½	3¾
lination of the boshes - - - -	59°	52°

e conical orifice called the tuyère, in which the tapered pipes are placed, for impart-
he blast, is seen near the bottom of the furnace, *fig.* 583, at A. Nose tubes of va-
sizes, from 2 to 4 inches in diameter, are applied to the extremity of the main
·pipe. Under A is the bottom of the hearth, which, in large furnaces, may be two
quare. B is the top of the hearth, about two feet six inches square. A B is the
t of the hearth, about six feet six inches. B shows the round bottom of the conical
nnel part, called in this country the *boshes*, standing upon the square area of the
h. c is the top of the boshes, which may be about 12 feet in diameter, and 8 feet
rpendicular height. D is the furnace top or mouth (*gueulard* in French), at which
aterials are charged. It may be 4½ feet in diameter. The line between c, D, is the
t of the internal cavity of the furnace, from the top of the boshes upwards, sup-
l to be 30 feet. A, D, is the total height of the interior of the furnace, reckoned at
eet. E E is the lining, which is built in the nicest manner with the best fire-bricks,
12 to 14 inches long, 3 inches thick, and curved to suit the circle of the cone. A
acy of 3 inches wide is left all round the outside of the first lining by the builder;
h is sometimes filled with coke dust, but more generally with sand firmly rammed.
void space in the brick-work is for the purpose of allowing for any expansion which
t occur, either by an increase in the bulk of the building, or by the pressure and
ht of the materials when descending to the bottom of the furnace. Exterior to E E
second lining of fire-bricks similar to the first. At F, on either side, is a cast-iron
, 8½ feet long, by 10 inches square, upon which the bottom of the arches is sup-
d. F, G, is the rise of the tuyère arch, which may be 14 feet high upon the outside,
18 feet wide. The extreme size of the bottom or sole of the hearth, upon each
of A, may be 10 feet square. This part and the boshing stones are preferably made
a coarse sandstone grit, containing large rounded grains of quartz, united by a sili-
rgillaceous cement.

e bottom of the hearth consists, first, of a course of the said gritstone; beneath

which is a layer of bedding sand, having, in its under
part, passages for the escape of the vapors generated
by damps; the whole being supported upon pillars of
brick.
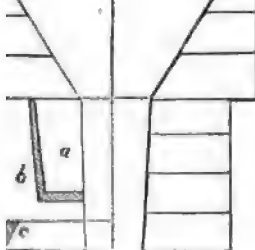
Fig. 584 represents the hearth and boshes, in a
vertical side section. *a* is the tymp stone, and *b* the
tymp plate for confining the liquid metal in the hearth.
The latter is wedged firmly into the side-walls of the
hearth; *c* is the dam-stone, which occupies the
whole breadth at the bottom of the hearth, excepting about 6
inches, which space, when the furnace is at work, is
filled, before every cast, with a strong binding sand.
This stone is faced outside by a cast-iron plate *d*, called
the dam-plate, of considerable thickness, and peculiar
shape. The top of the dam-stone, or rather the notch
of the dam-plate, lies from 4 to 8 inches under the

of the tuyère hole. The space under the tymp plate, for 5 or 6 inches down, is
aed full, for every cast, with strong loamy earth, or even fine clay; a process called
tymp stopping. The area of the base of this furnace being 38 feet, its extreme
it is 55 feet.

e blast furnaces of Staffordshire have always two tuyères, at least, placed on oppo-

site sides, but so pointed that the blast may not pursue directly opposite lines. In a furnace acting well in the neighborhood of Dudley, the one of the tuyères was 10 inches distant from the posterior wall of the hearth, and the other only four inches. In other furnaces with 3 tuyères, the side ones are placed, the one 16½ inches, and the other 6½ inches from the back. Three tuyères are seldom made to blow simultaneously. The third is brought into action only when the furnace seems to be choked up, and when it becomes necessary to clear it up by a powerful concussion. Too much pains cannot be bestowed on the masonry and brickwork of a blast furnace, and on the solidity of its foundation. In a soft ground it should rest on piles, so driven that the channel left beneath for the drainage of the building may be above any water level. Small passages should likewise be left throughout the body of the work, for the transpiration of moisture.

The blowing machines employed in Staffordshire are generally cast-iron cylinders, in which a metallic piston is exactly fitted as for a steam engine, and made in the same way. Towards the top and bottom of the blowing cylinders orifices are left covered with valves, which open inside when the vacuum is made with the cylinders, and afterwards shut by their own weight. Adjutages conduct into the iron globe or chest, the air expelled by the piston, both in its ascent and descent; because these blowing machines have always a double stroke.

The pressure of the air is made to vary through a very considerable range, according to the nature of the fuel and season of the year; for as in summer the atmosphere is more rarefied, it must be expelled with a compensating force. The limits are from 1½ pounds to 3½ pounds on the inch; but these numbers represent extreme proportions, the average amount in Staffordshire being 3 pounds. With this pressure a furnace usually works, which affords 60 tons of cast-iron in the week; and the pressure may be 2½ pounds on an average. The orifices, or nose-pipes, through which the air issues, also vary with the nature of the coke and the ore. In Staffordshire they are generally from 2 inches and 5 tenths to 2 inches and 8 tenths in diameter.

The blowing machines of Staffordshire are always impelled by steam engines. At Mr. Bagnall's works, two blast furnaces, 40 feet high, exclusive of the chimney or top, and two finery furnaces, are worked by a steam engine of 40 horses power; and therefore the power of one horse corresponds to the production of 2½ tons of cast iron per week, independently of the finery.

In South Wales, especially at Pontypool, there are slighter blast furnaces, whose upper portion is composed of a single range of bricks, each of which is 20 inches long, 4 thick, and 9 broad. The interior of the chimney represents an inverted cone. These furnaces derive solidity, and power to resist the expansions and contractions from change of temperature, by being cased, as it were, in horizontal hoops, placed 3 feet, or, even in some cases, only 6 inches asunder. These flat rings consist of four pieces, which are joined by means of vertical bars, that carry a species of ears or rings, into which the hoops enter, and are retained by bolts or keys. Instead of these ears, screw nuts are also employed for the junction. Each hoop is alternately connected to each of the eight vertical bars. The interior of these furnaces is the same as of the others; being generally from 12 to 14 feet diameter at the belly, and from 50 to 55 feet high. Though slight, they last as long as those composed of an outer body of masonry and a double lining of bricks; and have continued constantly at work for three years. In Wales also the blast furnaces are generally somewhat larger than in Staffordshire; because there the object being to refine the cast iron, they wish to procure as large a smelting product as possible. But in Staffordshire, a fine quality of casting iron is chiefly sought after, and hence their furnaces have less height, but nearly the same width.

In a blast apparatus employed at the Cyfartha works, moved by a 90 horse steam power, the piston rod of the blowing cylinder is connected by a parallelogram mechanism with the opposite end of the working beam of the steam engine. The cylinder is 9 feet 4 inches diameter, and 8 feet 4 inches high. The piston has a stroke 8 feet long, and it rises 13 times in the minute. By calculating the sum of the spaces percurred by the piston in a minute, and supposing that the volume of the air expelled is equal to only 96 per cent. of that sum, which must be admitted to hold with machines executed with so much precision, we find that 12,588 cubic feet of air are propelled every minute. Hence a horse power applied to blowing machines of this nature gives, on an average, 137 cubic feet of air per minute. The pressure on the air, as it issues, rarely exceeds two pounds on the square inch in the Welsh works.

At the establishment of Cyfartha, for blowing seven smelting furnaces, and the seven corresponding fineries, three steam engines are employed, one of 90 horse power, another of 80, and a third of 40; which constitutes in the whole a force of 210 horses, or 26 horses and ⅕ per furnace, supposing the fineries to consume one eighth of the blast. In the whole of the works of Messrs. Crawshay, the proprietors of Cyfartha, the power of about 350 horses is expended in blowing 12 smelting furnaces, and their subordinate fineries; which gives from 25 to 26 horses for each, allowing as before one eighth for the fineries. As these furnaces produce each about 60 tons of cast iron weekly, we find

that a horse power corresponds to 2 tons and a tenth in that time. Each of the furnaces consumes about 3567 cubic feet of air per minute. These works have been greatly increased of late years.

The following analyses of the English coal ironstones have been made by M. Berthier, at the school of mines in Paris.

	Rich Welsh Ore.	Poor Welsh Ore.	Rich Ore of Dudley, or gubbin.
Loss by ignition - - -	30·00	27·00	31·00
Insoluble residuum - -	8·40	22·03	7·66
Lime - - - - -	0·0	6·00	2·66
Peroxyde of iron - - -	60·00	42·66	58·33
On calculating the quantities of carbonate of iron, and metallic iron, to which the above peroxyde corresponds, we have :—			
Carbonate of iron - -	88·77	65·09	85·20
Metallic iron - - -	42·15	31·38	40·45

The mean richness of the ores of carbonate of iron of these coal basins is not far from 33 per cent. About 28 *per cent.* is dissipated on an average, in the roasting of the ores. Every ferruginous clay-stone is regarded as an iron ore, when it contains more than 20 per cent. of metal; and it is paid for according to its quality, being on an average at 12 shillings per ton in Staffordshire. The gubbin, however, fetches so high a price as 16 or 17 shillings. The ore must be roasted before it is fit for the blast furnace, a process carried on in the open air. A heap of ore mingled with small coal (if necessary) is piled up over a stratum of larger pieces of coal; and this heap may be 6 or 7 feet high, by 15 or 20 broad. The fire is applied at the windward end, and after it has burned a certain way, the heap is prolonged at the other extremity, as far as the nature of the ground or convenience of the work requires. The quantity of coal requisite for roasting the ore varies from one to four hundred weight per ton, according to the proportion of bituminous matter associated with the iron-stone. The ore loses in this operation from 25 to 30 per cent. of its weight. Three and a quarter tons of crude ore, or two and a quarter tons of roasted ore, are required to produce a ton of cast-iron; that is to say, the crude material yields on an average 30·7 per cent., and the roasted ore 44·4 of pig metal. In most smelting works in Staffordshire, about equal weights of the rich ore in round nodules called *gubbin*, and the poorer ore in cakes called *blue flat*, are employed together in their roasted state; but the proportions are varied, in order to have a uniform mixture, capable of yielding from 30 to 33 per cent. of metal.

The transition or carboniferous limestone of Dudley is used as the flux; it is compact and contains little clay. The bulk of the flux is made nearly equal to that of the ore. To treat two tons and a quarter of roasted ore, which furnish one ton of pig iron, 19 hundred weight of limestone are employed; constituting nearly 1 of limestone for 3 of unroasted ore. The limestone costs 6 shillings the ton.

Carbonized pitcoal or coke was, till within these few years, the sole combustible used in the blast furnaces of Staffordshire.

The coal is distributed in circular heaps, about 5 feet diameter, by 4 feet high; and the middle is occupied by a low brick chimney, piled with loose bricks, so open as to leave interstices between them, especially near the ground. The larger lumps of coal are arranged round this chimney, and the smaller towards the circumference of the heap. When every thing is adjusted, a kindling of coals is introduced into the bottom of the brick chimney; and to render the combustion slow, the whole is covered over with a coat of coal dross, the chimney being loosely closed with a slab of any kind. Openings are occasionally made in the crust and afterwards shut up, to quicken and retard the ignition at pleasure, during its continuance of 24 hours. Whenever the carbonization has reached the proper point for forming good coke, the covering of coal dross is removed, and water is thrown on the heap to extinguish the combustion; a circumstance deemed useful to the quality of the coke. In this operation the Staffordshire coal loses the half of its weight, or two tons of coal produce one of coke.

As soon as the blast furnace gets into a regular heat, which happens about 15 days or three weeks after fires have been put in it, the working consists simply in charging it, at the opening in the throat, whenever there is a sufficient empty space; the only rule being to keep the furnace always full. The coke is measured in a basket, thirteen of which go to the ton. The ore and the flux (limestone) are brought forwards in wheel-barrows of sheet iron. In 24 hours, there are thrown into a furnace such as *fig.* 582, 14½ tons of coke, 16 tons of roasted ore, and 6¾ tons of limestone; from which about 7 tons of pig iron are procured. This is run off every 12 hours; in some works the blast is suspended during the discharge. The metal intended to be converted into

bar iron, or to be cast again into moulds, is run into small pigs 3 feet long, and 4 inches diameter; weighing each about 2 hundred weight and a half.

The disorders to which blast furnaces are liable have a tendency always to produce white cast-iron. The color of the slag or scoriæ is the surest test of these derangements, as it indicates the quality of the products. If the furnace is yielding an iron proper for casting into moulds, the slag has a uniform vitrification, and is slightly translucid. When the dose of ore is increased in order to obtain a gray pig iron, fit for fabrication into bars, the slag is opaque, dull, and of a greenish-yellow tint, with blue enamelled zones. Lastly, when the furnace is producing a white metal, the slags are black, glassy, full of bubbles, and emit an odor of sulphureted hydrogen. The scoriæ from a coke are much more loaded with lime than those from a charcoal blast furnace. This excess of lime appears adapted to absorb and carry off the sulphur, which would otherwise injure the quality of the iron. The slags, when breathed on, emit an argillaceous odor.

A blast furnace of 50 or 60 feet in height gives commonly from 60 to 70 tons of cast-iron per week; one from 50 to 55 feet high, gives 60 tons; two united of 45 feet produce together 100 tons; and one of 36 feet furnishes from 30 to 40. A blast furnace should go for four or five years without needing restoration. From $3\frac{1}{2}$ to 4 tons of coal, inclusive of the coal of calcination, are required in Staffordshire to obtain one ton of cast-iron; and the expense in workmen's wages is about 15 shillings on that quantity.

At the Cyfartha works of Messrs. Crawshay in South Wales, the average price of the lithoid carbonate of iron, ready for roasting, is only 7s. 6d. a ton, and its richness is about 33 per cent. The furnaces for roasting the ore in that country are made in the form of cylinders, placed above an inverted cone. The cylindrical part is 6 feet high and wide, and the cone is about 4 feet high, with a base equal to that of the cylinder; towards the bottom or narrowest part of the inverted cone, there is an aperture which terminates in an outlet on a level with the bottom of the terrace in which the furnace is built. Sometimes, however, all the roasting furnaces are in a manner combined into one, which resembles a long pit about 6 feet in width and depth, and whose bottom presents a series of inverted hollow quadrangular pyramids, 6 feet in each side, and 4 deep. The bottom or apex of each of these pyramids communicates with a mouth or door-way that opens on a lower terrace, through which the ore falls in proportion as it is roasted; and whence it is wheeled and tumbled into the throat of an adjoining blast furnace, on the same level with the terrace; for in Wales the blast furnace is generally built up against the face of a hill, which makes one of its fronts. The above roasting furnaces, which closely resemble lime-kilns, after being filled with alternate strata of small coal and ore, are set on fire; and the roasted ore is progressively withdrawn below, as already mentioned.

The product of coke from a certain weight of coal is greater in Wales than in Staffordshire, though the mode of manufacture is the same. At Pen-y-Darran, for example, 5 of coal furnish $3\frac{1}{2}$ of coke; or 100 give 70; at Dowlais 100 of coal afford 71 of coke, and the product would be still greater if more pains were bestowed upon the process. At Dowlais, coal costs only 2 shillings a ton; at Cyfartha, it is worth from 2s. 6d. to 5 shillings. About 2 tons of coke are employed in obtaining 1 ton of cast-iron.

According to M. Berthier's analysis, the slag or cinder of Dowlais consists of silica, 40·4; lime, 38·4; magnesia, 5·2; alumina, 11·2; protoxyde of iron, 3·8; and a trace of sulphur. He says that the silica contains as much oxygen as all the other bases united; or is equivalent to them in saturating power; and to the excess of lime he ascribes the freedom from sulphur, and the good quality of the iron produced. The specimen examined was from a furnace at Merthyr-Tydvil. Other slags from the same furnace, and one from Dudley, furnished upwards of 2 per cent. of manganese. Those which he analyzed from Saint Etienne, in France, afforded about 1 per cent. of sulphur.

The consumption of coal in the Welsh smelting furnaces may be estimated, on an average, at 3 tons per ton of cast-iron; corresponding to 2·1 of their coke. From this economy in the quantity of fuel, as well as from its cheapness and that of the iron ore, the iron of South Wales can be brought into the market at a much lower rate than that of any other district. These blast furnaces remain in action from 5 to 10 years; at the end of which time, only their interior surface has to be repaired. The lining of the upper part lasts much longer; for examples are not wanting of its holding good for nearly 40 years.

One of the greatest improvements ever made by simple means in any manufacture is the employment of hot air, instead of the ordinary cold air of the atmosphere, in supplying the blast of furnaces for smelting and founding iron. The discovery of the superior power of a hot over a cold blast in fusing refractory lumps of cast-iron was accidentally observed by my pupil, Mr. James Beaumont Neilson, engineer to the Glasgow gas works, about the year 1827, at a smith's forge in that city, and it was made the subject of a patent in the month of September of the following year. No particular construction of apparatus was described by the inventor by which the air was to be

heated, and conveyed to the furnace; but it was merely stated that the air may be heated in a chamber or closed vessel, having a fire under it, or in a vessel connected in any convenient manner with the forge or furnace. From this vessel the air is to be forced by means of bellows into the furnace. The quantity of surface which a heating furnace is required to have for a forge, is about 1260 cubic inches; for a cupola furnace, about 10,000 cubic inches. The vessel may be enclosed in brickwork, or fixed in any other manner that may be found desirable, the application of heated air in any way to furnaces or forges, for the purposes of working iron, being the subject claimed as constituting the invention.

Wherever a forced stream of air is employed for combustion, the resulting temperature must evidently be impaired by the coldness of the air injected upon the fuel. The heat developed in combustion is distributed into three portions; one is communicated to the remaining fuel, another is communicated to the azote of the atmosphere, and to the volatile products of combustion, and a third to the iron and fluxes, or other surrounding matter to be afterwards dissipated by wider diffusion. This inevitable distribution takes place in such a way, that there is a nearly equal temperature over the whole extent of a fire-place, in which an equal degree of combustion exists.

We thus perceive that if the air and the coal be very cold, the portions of heat absorbed by them might be very considerable, and sufficient to prevent the resulting temperature from rising to a proper pitch; but if they were very hot they would absorb less caloric, and would leave more to elevate the common temperature. Let us suppose two furnaces charged with burning fuel, into one of which cold air is blown, and into the other hot air, in the same quantity. In the same time, nearly equal quantities of fuel will be consumed with a nearly equal production of heat; but notwithstanding of this, there will not be the same degree of heat in the two furnaces, for the one which receives the hot air will be hotter by all the excess of heat in its air above that of the other, since the former air adds to the heat while the latter abstracts from it. Nor are we to imagine that by injecting a little more cold air into the one furnace, we can raise its temperature to that of the other. With more air indeed we should burn more coals in the same time, and we should produce a greater quantity of heat, but this heat being diffused proportionally among more considerable masses of matter, would not produce a greater temperature; we should have a larger space heated, but not a greater intensity of heat in the same space.

Thus, according to the physical principles of the production and distribution of heat, fires fed with hot air should, with the same fuel, rise to a higher pitch of temperature than fires fed with common cold air. This consequence is independent of the masses, being as true for a small stove which burns only an ounce of charcoal in a minute, as for a furnace which burns a hundred weight; but the excess of temperature produced by hot air cannot be the same in small fires as in great; because the waste of heat is usually less the more fuel is burned.

This principle may be rendered still more evident by a numerical illustration. Let us take, for example, a blast furnace, into which 600 cubic feet of air are blown per minute; suppose it to contain no ore, but merely coal or coke, and that it has been burning long enough to have arrived at the equilibrium of temperature, and let us see what excess of temperature it would have if blown with air of 300° C. (572° F.), instead of being blown with air at 0° C.

600 cubic feet of air under the mean temperature and pressure, weigh a little more than 45 pounds avoirdupois; they contain 10·4 pounds of oxygen, which would burn very nearly 4 pounds of carbon, and disengage 16,000 times as much heat as would raise by one degree Cent. the temperature of two pounds of water. These 16,000 portions of heat, produced every minute, will replace 16,000 other portions of heat, dissipated by the sides of the furnace, and employed in heating the gases which escape from its mouth. This must take place in order to establish the assumed equilibrium of caloric.

If the 45 pounds of air be heated beforehand up to 300° C., they will contain about the eighth part of the heat of the 16,000 disengaged by the combustion, and there will be therefore in the same space one eighth of heat more, which will be ready to operate upon any bodies within its range, and to heat them one eighth more. Thus the blast of 300° C. gives a temperature which is nine eighths of the blast at zero C., or at even the ordinary atmospheric temperature; and as we may reckon at from 2200° to 2700° F. (from 1200° to 1500° C.), the temperature of blast furnaces worked in the common way, we perceive that the hot air blast produces an increase of temperature equal to from 270° to 360° F.

Now in order to appreciate the immense effects which this excess of temperature may produce in metallurgic operations, we must consider that often only a few degrees more temperature are required to modify the state of a fusible body, or to determine the play of affinities dormant at lower degrees of heat. Water is solid at 1° under 32° F.; it is liquid at 1° above. Every fusible body has a determinate melting point, a very low

degrees above which it is quite fluid, though it may be pasty below it. The same observation applies to ordinary chemical affinities; charcoal, for example, which reduces the greater part of metallic oxydes, begins to do so only at a determinate pitch of temperature, under which it is inoperative, but a few degrees above, it is in general lively and complete. It is unnecessary, in this article, to enter into any more details to show the influence of a few degrees of heat, more or less, in a furnace, upon chemical operations, or merely upon physical changes of state.

These consequences might have been deduced long ago, and industry might thus have been enriched with a new application of science; but philosophers have been and still
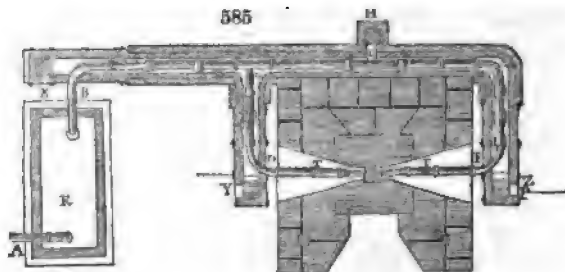
are too much estranged from the study of the useful arts, and content themselves too much with the minutiæ of the laboratory or theoretic abstractions. Within the space of 7 years, the use of the hot blast has been so much extended in Great Britain, as to have enabled many proprietors of iron works to add 50 per cent. to their weekly production of metal, to diminish the expenses of smelting by 50 per cent., and, in many cases, to produce a better sort of cast iron from indifferent materials.
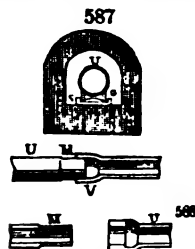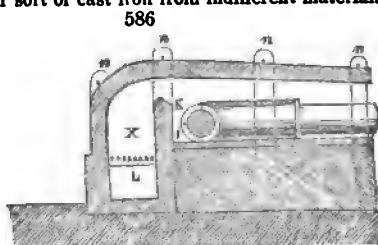
The figures here given represent the blast furnace, and all the details of the air heating, at one view. *Fig.* 583 is a vertical section of the furnace and the apparatus; *fig.* 585 represents the plan at the height of the line 1, 2, of *fig.* 583. The blowing machine, which is not shown in this view, injects the air through the pipe A, into the regulator chamber R, *fig.* 585; the air thence issues by the pipe B, proceeds to c, where it is subdivided into two portions; the one passes along the pipe C D to get to the tuyère T, the other passes behind the furnace, and arrives at the tuyère T' by the pipe C E T'.

These pipes are distributed in a long furnace or flue, whose bottom, sides, and top are formed with fire-brick, where they are exposed to the action of the flame of the three fires X, Y, Z. The flame of the fire X plays round the pipe B at its entrance into the flue, and quits it only to go into the chimney H; that of the fire Y acts from the point D to the same chimney, passing by the elbow C; that of the fire Z acts equally upon T and H, in passing by the elbow E.

Disposition of the fires and furnace.—Fig. 586 represents, upon a scale three times larger than *fig.* 585, the section of the

fire x, of which the plan is seen in *fig.* 585, and the elevation in *fig.* 583; as also in the outside view of the blast furnace, *fig.* 589.

The grate is at L; the fuel is introduced by the door P, *fig.* 583; the flame rises above the bridge I K, and proceeds along the vaulted flue towards the chimney H. Through a length of about 13 feet, including the grate, the furnace is on each side supported by oblong plates of cast-iron, which are bound together by 4 upright ribbed or feathered bars, also on each side; these bars, *n*, being bound together by iron rods furnished with screw nuts at their ends (*figs.* 583, 585, 586). Beyond this distance, the outside of the furnace is mere brickwork.

The fires Y and z have exactly a like disposition with the above.

Fig. 586 indicates the dimensions and the curvature of the arch above the grate, near the bridge; *fig.* 587 represents the section of the furnace and of the pipe beyond the cast-iron casing.

I find that the furnace is only about 3 feet wide at the bottom, and that the elevation of the arch above the bottom is no more than 30 inches. Perhaps it might be made a little wider with advantage; the combustion would be more vigorous and effective; and if the sides also were a little thicker, the heat would be better confined.

The distance from the fire-place x to the chimney H, is 43½ feet.

—	—	Y to the point c, is	13 —
—	—	z to the chimney, is	29 — including the turn of the elbow E.

Distribution of the pipes.—At B the pipe is 18 inches diameter outside, and one inch thick of metal, and it tapers to c; from c to D and from D to c the pipes are only 11 inches in external diameter, and three fourths of an inch thick; they are 5 feet long, and are united by two kinds of joints; the ordinary ones, and those of compensation, to give play for the expansion and contraction. One of these is seen between B and c, one between c and D, one between c and E, and a fourth between E and F. These pipes and their adjustment are seen more at large in *fig.* 588; U V is one of these pipes, its widened mouth receives the extremity M of the preceding pipe. These pieces are truly bored and turned to fit each other, and slide out and in like telescope tubes, by the effect of dilatation and contraction of the pipes with changes of temperature.

At certain distances castors or friction-rollers of cast-iron are placed to carry the pipes, which roll upon oblong plates of cast-iron laid upon the floor of the flues. These castors are shown at *a, b, c, d, e, f, g, fig.* 585; one of them is shown separate upon a larger scale at G, in *fig.* 587, as also the plate or rail s, on which it runs.

The tuyères T T′ are adjusted into the pipe behind them; this is truly bored, so as to allow the thick end of the tuyère to slide tightly backwards and forwards in it, like a piston in the barrel of a pump; a diaphragm moreover prevents the tuyère from being drawn or forced entirely out of its tube. At the side of this tube there is a small orifice, which may be shut or opened at pleasure with a stopcock or screw-plug: it serves to try the degree of heat of the air-blast; if a lead wire does not melt when held at this hole, the temperature is reckoned too low; being under the 612th degree of Fahrenheit. The nozzles are 2 inches in diameter.

Near the fire-places of the air-heating furnaces the pipes are at a cherry-red heat; and lest they should be burned, they are there coated with a lute of fire-clay, as shown near x, in *fig.* 586. By this means the air is kept up at the heat of 350° C., or 662° F., a little above the boiling point of quicksilver.

Quantity of air and pressure.—The blowing-machine belonging to the above blast-furnace is moved by a water wheel of 22 horse power; the pistons are 4 feet in diameter, have a 3½-feet stroke, work double, and expel 1200 cubic feet of air in the minute; or 600 cubic feet for each nozzle. The pressure of the air is equivalent to no more than 2 or 2¼ inches of mercury; formerly with cold air it amounted to 3½ inches. This furnace yields, upon an average, 5¼ tons of cast-iron daily, and consumes 1½ cwt. of coke for each cwt. of cast-iron produced; being 7 tons of coke *per diem.*

The consumption of the three flue fires is 30 pounds of small coal, for 100 pounds of cast-iron produced, which may be reckoned equivalent to 15 pounds of coke; hence altogether each ton of cast-iron requires for its production 1½ tons of coke.

The same furnace worked with the cold blast, the same pressure, and the same ores, produced only 3½ tons of cast-iron daily, with an expenditure of 2·55 of coke for 1 of cast-iron; in which case the coke amounted to 9 tons daily.

The returns by the hot blast compared with those by the cold, are therefore as the numbers 3 and 2, which shows an advantage by the former plan of 50 per cent. The consumption of fuel in the two cases is as 8 to 9, being a saving in this article of about 11 per cent. Coke is used on account of sulphur in the coal.

Hot-blast heated by the flame of the furnace mouth.—This system is mounted in Staffordshire. The heating apparatus is there set immediately upon the mouth of the furnace; and is composed of two large cast-iron cylinders of the same length, the one within

the other, leaving a space between them. This annular interval amounts to 16 inches and it is closed at top and bottom: but the innermost cylinder is open at both ends, and forms, indeed, the vent of the chimney or furnace. It carries nine rows of pipes, three in each row, which cross its interior, and open into the annular space.

The flame of the furnace passes between the intervals of the cross pipes, heating them, and also the two upright cylinders with which they are connected. The air of the blowing machine arrives by a vertical pipe, which is placed at the back of the furnace; it enters into the above annular space, and thence circulates, with more or less velocity, through the 27 cross tubes, upon which the flame is continually playing; lastly, it is drawn through to the bottom of the annuiar space; the two tubes which conduct it to the two tuyères, pass down within the brickwork of the furnace, and thus prevent the dissipation of its heat.

Below this heating apparatus there is a door for putting the charges into the furnace.

The above arrangement does not seem to be the best for obtaining the greatest possible heat for the blast, nor for favoring the free action of the furnace; but it illustrates perfectly well the principle of this application. A serpentine movement in a long bent hot channel would be much better adapted for communicating heat to so bad a conductor as air is known to be.

In the month of July, 1836, I paid a visit to Codner Park and Butterly works, in Derbyshire, belonging to the eminent iron-masters, Messrs. Jessop & Co., where I was kindly permitted not only to study the various processes of the manufacture of cast and wrought iron, but to inspect the registers of the products of cast iron in their blast furnaces for several years back. It appeared that in the year 1829, only 29 tons of cast-iron were made weekly in each of the blast furnaces at Codner Park. They were then worked with coke, and blown with cold air. Each ton of iron required for its production, at that time, 6·82 tons of coals, made into coke for smelting; with 2·64 of roasted iron ore (carbonate), called mine; and 0·87 of limestone, the *castine* of the French.

In 1835 and 1836, the same furnaces turned out weekly 49 tons of cast-iron each; and every ton of iron required for its production only 3 tons of coal (not made into coke); 2·72 tons of mine; and 0·77 of lime.

In 1829, and for many years before, as well as one or two after, each ton of coals is said to have cost for coking the sum of 6s., whence the 6·82 tons of coals then converted into coke for smelting one ton of iron, cost fully 40s. in coking alone, in addition to their prime cost. The saving in this respect, therefore, is 40s. upon each ton of iron, besides the saving of fully half the coal, and the increased produce of nearly 60 per cent. of metal per week. The iron-master pays the patentee 1s. upon every ton of iron which he makes, and, at the prices of 1836, he lessened his expenses by at least 30s. or 40s. per ton by the patent improvement.

The following tabular view of the progression in the management and results of the hot blast, is given by M. Dufrènoy, after visiting the various iron works in this country where it had been introduced.

"At the Clyde iron works, near Glasgow; in 1829, when the combustion was effected by the cold air blast,—

				Coal.		
				Tons.	cwt.	lbs.
There were consumed, for smelting, 3 tons of coke, equivalent to				6	13	0
— for the blowing engine	-	-	-	1	0	7
		Total coal per ton of iron		7	13	7
		Limestone	-	0	10½	0

In 1831, with the hot blast at 450° F., coke being still used in smelting,—
There were consumed, for smelting, 1 ton, 18 cwt. of coke, equivalent to

lent to	-	-	-	4	6	0
— for heating the air, 5 cwt.						
— for the blowing engine, 7 cwt. 4 lbs.				0	12	4
		Total coal per ton of iron		4	18	4
		Limestone	-	0	9	0

In July, 1833, with the hot blast at 612° F., raw coal alone being used for smelting,—

There were consumed : for smelting	-	-	-	2	0	0
— for heating the air	-	-	-	0	8	0
— for the blowing engine	-	-	-	0	11	2
		Total coal per ton of iron		2	19	2
		Limestone	-	0	7	0

"At the last period the use of hot air had increased the make of the furnaces by more than one third, and had consequently produced a great saving of expense in the article of labor. The quantity of blast necessary for the furnaces was also sensibly diminished; for a blowing engine of seventy-horse power, which, in 1829, served only for three blast furnaces, was now sufficient for the supply of four.

"On comparing these several results, we find that the economy of fuel is in proportion to the temperature to which the air is raised. As for the actual saving, it varies in every work, according to the nature of the coal, and the care with which the operation is conducted.

"This process, though it has been four years in use in the works near Glasgow (which it has rescued from certain ruin), has scarcely passed the borders of Scotland; the marvellous advantages, however, which it has produced, are beginning to triumph over prejudice, and gradually to extend its use into the different English iron districts. There are one-and-twenty works, containing altogether sixty-seven blast furnaces, in which hot air is used. The pig iron run out of these furnaces is generally No. 1, and is fit for making the most delicate castings. This process is equally applicable to forge pigs for the manufacture of bar iron; since in order to obtain this quality of iron, it is only necessary to alter the proportion of fuel and mineral. In the forges of the Tyne iron-works, near Newcastle, and of Codner Park, near Derby, pigs made in furnaces blown by hot air, are alone used in the manufacture of bar iron.

"In the side of the tuyère pipe a small hole is made, by means of which the heat of the air may be ascertained at any moment. This precaution is indispensable, it being of importance to the beneficial use of hot air, that it be kept at a uniformly high temperature. With a proper apparatus the air is raised to 612 degrees Fahr., which is a greater heat, by several degrees, than is necessary for the fusion of lead."

"At Calder works the consumption of fuel has diminished in the proportion of 7 tons 17 cwts. to 2 tons 2 cwts. There has also been a great diminution of expense in limestone, of which only 5¼ cwts. are now used, instead of 13 cwts., which were used in 1828. This decrease results, as I have already said, from the high temperature which the furnace has acquired since the introduction of hot air.

"The quantity of blast has been reduced from 3500 cubic feet per minute, to 2627 cubic feet; the pressure also has been reduced from 3¼ to 2¾ lbs."

Of the refinery of cast-iron, or its conversion into bar-iron, in England.—This operation is naturally divisible into three distinct parts. The first, or the finery properly speaking, is executed in peculiar furnaces called *running out fires;* the second operation completes the first, and is called *puddling;* and the third consists in welding several iron bars together, and working them under forge hammers, and between rolls.

1. The *finery furnaces* are composed of a body of brickwork, about 9 feet square; rising but little above the surface of the ground. The hearth, placed in the middle, is two feet and a half deep; it is rectangular, being in general, 3 feet by 2, with its greatest side parallel to the face of the tuyères; and it is made of cast iron in four plates. On the side of the tuyères there is a single brick wall. On the three other sides, sheet iron doors are placed, to prevent the external air from cooling the metal, which is almost always worked under an open shed, or in the open air, but never in a space surrounded by walls. The chimney, from 15 to 18 feet high, is supported upon four columns of cast iron; its lintel is four feet above the level of the hearth, in order that the laborers may work without restraint.

The number of tuyères is from two to three; they are placed at the height of the lip of the crucible or hearth, and distributed so as to divide its length into equal parts; their axes being inclined towards the bottom, at an angle of from 25° to 30°, so as to point upon the bath of melted metal as it flows. The cast-iron nose-pipe is incased, and water is made to circulate in the hollow space by means of cylindrical tubes; being introduced by one tube, and let off by another, so as to prevent the tuyères from getting burned in the process.

Two nozzles are usually placed in each tuyère, to render the blast constant and uniform; and for the same end, the air impelled by the bellows, is sometimes received at first in a regulator. The quantity of air blown into the fineries is considerable; being nearly 400 cubic feet per minute for each finery; or about the eighth part of the consumption of a blast furnace.

The finery furnace, or running out fire, is represented in *figs.* 590 and 591. It is a smelting hearth, in which by first fusing and then cooling gray cast iron in a peculiar way, it is converted into white cast iron, called fine iron, or fine metal, of the quality of forge pig, for making malleable iron by the puddling process. The furnace resembles the forge hearth employed in Germany and France for converting forge pig into wrought iron; but it differs, particularly in this, that the fused iron is run out into an oblong iron trough, for sudden congelation.

a is the air-chest, in communication with the blowing cylinder, or bellows; the air

being conducted through at least two blast pipes to the fire, and sometimes through even 4 or 6 pipes. *b* is the side of the furnace, corresponding to the tuyère plates, in
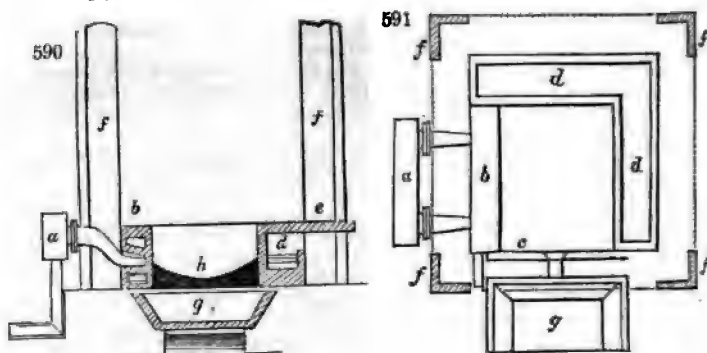
which are the openings for the blast pipes. All the sides of the furnace are hollow, and are kept cool by the circulation of water through the cavity between them. *c* is the front wall of the furnace, having a strong cast iron plate containing the tap holes for running off the melted metal. *d d* is the exterior wall of the furnace, which corresponds to the *contre-vent* and ash-hearth of the French refining forge. *e*, is the top plate upon which the coke is piled up in store. *f f, f f*, iron props of the chimney, (not shown in this view). *g*, cast iron trough into which the fine iron is run off in fusion; which is sometimes made in one piece, but more usually in separate plates joined together. Beneath this mould a stream of water is made to flow. *h* is the bottom of the hearth, covered with sand.

In the finery process, the hearth or crucible of the furnace is filled with coke; then six pigs of cast iron are laid horizontally on the hearth, namely, four of them parallel to the four sides, and two in the middle above; and the whole is covered up in a dome-form, with a heap of coke. The fire is now lighted, and in a quarter of an hour the blast is applied. The cast iron flows down gradually, and collects in the crucible; more coke being added as the first quantity burns away. This operation proceeds by itself; the melted metal is not stirred about, as in some modes of refinery, and the temperature is always kept high enough to preserve the metal liquid. During this stage the coals are observed continually heaving up, a movement due in part to the action of the blast, and in part to an expansion caused in the metal by the discharge of gaseous oxyde of carbon. When all the pig iron is collected at the bottom of the hearth, which happens commonly at the end of two hours, or two and a half, the tap hole is opened, and the *fine* metal flows out with the slag, into the loam-coated pit, on a plate 10 feet long, 3 broad, and from 2 inches to 2½ thick. A portion of the slag forms a small crust on the surface of the metal; but most part of it collects in a basin scooped out at the bottom of the pit, into which the fine metal is run.

A large quantity of water is thrown on the fine metal, with the view of rendering it brittle, and perhaps of partially oxydizing it. This metal suddenly cooled, is very white, and possesses in general a fibrous radiated texture; or sometimes a cellular, including a considerable number of small spherical cavities, like a decomposed amygdaloid rock. If the cast iron be of bad quality, a little limestone is occasionally used in the above operation.

Three samples of cinder, analyzed by Berthier, gave.

Silica 0·276 ; protox. of iron, 0·612 ; alumina, 0·040 ; phosp. acid, 0·072, Dudley.
— 0·368   —   0·610   —   0·015; puddling of Dowlais.
— 0·421   —   0·520   —   0·033 ; ditto.

The remarkable fact of the presence of phosphoric acid, shows how important this operation is to the purification of the iron. The charge varies from a ton and a quarter to a ton and a half of pigs; and the loss by the process varies from 12 to 17 per cent.

The *fine metal* is broken into fragments, and sent to the puddling furnace after the product of each operation has been weighed. The coal consumed in the fine metal process is from 4 to 5 hundred weight for the ton of cast iron. About 10 tons may be refined *per diem*, a quantity somewhat greater than the supply from a blast furnace; but the fineries are not worked on the Sundays; and therefore a smelting furnace just keeps one of them in play. Whatever care be taken in this process, the bar iron finally resulting is never so good as if wood charcoal had been used in the refinery; and hence in making sheet iron for the tin plate manufacture, wood charcoal is substituted for coke in one Welsh establishment. The cast iron treated with charcoal, gets into close

or lumps in the finery furnace, which are lifted out, set under the hammer, and flattened into thin cakes.

The main effect of the finery process, is probably the separation of the plumbaginous part of the charcoal, which is disseminated through the gray cast iron in a state of imperfect chemical combination. When that is removed the metal becomes more homogeneous, having no crystalline carbon present to counteract its transition into pure iron ; much of the silica and manganese are also vitrified together, and run off in the finery cinder.

2. The *puddling furnace* is of the reverberatory form. It is bound generally with iron, as represented in the side view, *fig.* 592, by means of horizontal and vertical bars, which

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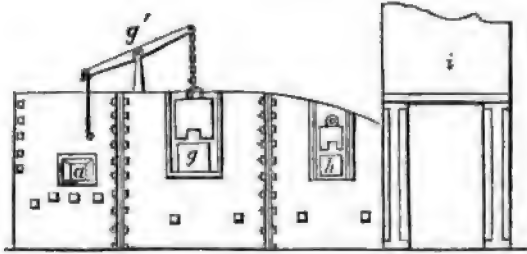
are joined together and fixed by wedges, to prevent them from starting asunder. Very frequently, indeed, the reverberatory furnaces are armed with cast-iron plates over their whole surface. These are retained by upright bars of cast iron applied to the side walls, and by horizontal bars of iron, placed across the arch or roof. The furnace itself is divided interiorly into three parts ; the *fire-place*, the *hearth*, and the *flue*. The *fire-place* varies from 3½ to 4½ feet long, by from 2 feet 8 inches to 3 feet 4 inches wide. The door way by which the coke is charged, is 8 inches square, and is bevelled off towards the outside of the furnace. This opening consists entirely of cast iron, and has a quantity of coal gathered round it. The bars of the fire grate are moveable, to admit of more readily clearing them from ashes.

Fig. 593 is a longitudinal section referring to the elevation ; *fig.* 592, and *fig.* 594,

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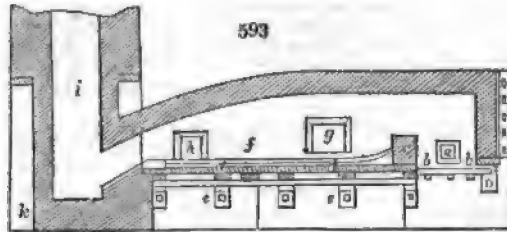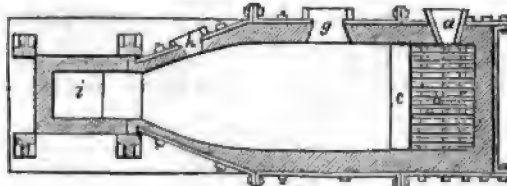
is a ground plan. When the furnace is a single one, a square hole is left in the side of the fire-place opposite to the door, through which the rakes are introduced, in order to be heated.

a is the fire door ; *b*, the grate ; *c*, the fire bridge ; *d d*, cast-iron hearth plates, resting upon cast-iron beams *e e*, which are bolted upon both sides to the cast-iron binding plates of the furnace. *f* is the hearth covered with cinders or sand ; *g*, is the main working door, which may be opened and shut by means of a lever *g'*, and chain to move it up and down. In this large door there is a hole 5 inches square, through which the iron may be worked with the paddles or rakes ; it may also be closed air-

in order to prevent the metal from running together as it softens, he removes it from the vicinity of the fire-bridge. When the whole of the fine metal has thus got reduced to a pasty condition, he must lower the temperature of the furnace, to prevent it from becoming more fluid. He closes the damper, takes out a portion of the fire, and the ribs of the grate, and also throws a little water sometimes on the semi-fused mass. He then works about with his paddle the clotty metal, which swells up, with the discharge of gaseous oxyde of carbon, burning with a blue flame, as if the bath were on fire. The metal becomes finer by degrees, and less fusible; or in the language of the workmen, it begins to get *dry*. The disengagement of the oxyde of carbon diminishes, and soon stops. The workmen continue meanwhile to puddle the metal till the whole charge be reduced to the state of incoherent sand; and at that time, the ribs of the grate are replaced, the fire is restored, and the register is progressively opened up. With the return of the heat, the particles of metal begin to agglutinate, the charge becomes more difficult to raise, or in the laborers' language, it *works heavy*. The refining is now finished, and nothing remains but to gather the iron into balls. The founder with his paddle takes now a little lump of metal, as a nucleus, and makes it roll about on the surface of the furnace, so as to collect more metal, and form a ball of about 60 or 70 pounds weight. With a kind of rake, called in England a *dolly*, and which he heats beforehand, the workman sets this ball on that side of the furnace most exposed to the action of the heat, in order to unite its different particles; which he then squeezes together to force out the scoriæ. When all the balls are fashioned, (they take about 20 minutes work,) the small opening of the working door is closed with a brick, to cause the heat to rise, and to facilitate the welding. Each ball is then lifted out, either with tongs, if roughing rollers are to be used, as in Wales, or with an iron rod welded to the lump as in Staffordshire. Thus we see that the operation lasts in whole from 2 hours to 2½; in a quarter of an hour, the fine metal melts at its edges, when the puddling begins, in order to effect its division; at the end of an hour or an hour and a half, the metal is entirely reduced to a sand; a state that is kept up for half an hour by continual stirring; and finally, the balling operation takes nearly the same time.

The charge for each operation is from 3½ to 4 hundred weight; and sometimes the cuttings of bar-ends are introduced, which are puddled apart. The loss of iron is here very variable, according to the degree of skill in the workman, who by negligence may suffer a considerable body of iron to scorify or to flow into the hearth and raise the bottom. In good working, the loss is from 8 to 10 per cent. In Wales, the consumption of coal is estimated at one ton for every ton of fine metal. About five puddling furnaces are required for the service of one smelting furnace and one finery. The hearth of the puddling furnace should be exposed to heat for 12 hours before the work begins on the Mondays; and on the Saturdays, the old sole must be cleared out, by melting it off, and running it out by the floss-hole.

Mr. Schafthault obtained, in May, 1835, a patent for the conversion of cast into wrought iron, by adding a mixture of black oxyde of manganese, common salt, and potter's clay, in certain small portions, successively, to the melting iron in the puddling furnace.

The reheating furnaces, balling furnaces, or mill furnaces, are analogous to the puddling furnaces, but only of larger dimensions.

The wood charcoal forge hearth is employed for working up scrap iron into boiler plate, &c. Here 22 bushels of charcoal are consumed in making one ton of iron of that description, from boiler plate parings.

Machines for forging and condensing the iron.—In England there are employed for the forging and drawing out of the iron, cast-iron hammers of great weight, and cylinders of different dimensions, for beating out the balls, or extending the iron into bars, as also powerful shears. These several mechanisms are moved either by a steam engine, as in Staffordshire, and in almost all the other counties of England, or by water-wheels when the localities are favorable, as in many establishments in South Wales. We shall here offer some details concerning these machines.

The main driving shaft usually carries at either end a large toothed wheel, which communicates motion to the different machines through smaller toothed wheels. Of these, there are commonly six, four of which drive four different systems of cylinders, and the two others work the hammer and the shears. The different cylinders of an iron work should never be placed on the same arbor, because they are not to move together, and they must have different velocities, according to their diameter. In order to economize time and facilitate labor, care is taken to associate on one side of the motive machine the hammer, the shears, and the reducing cylinders; and on the other side to place the several systems of cylinders for drawing out the iron into bars. For the same reason the puddling furnaces ought to be grouped on the side of the hammer; and the reheating furnaces on the other side of the works.

subdivided into several varieties, according to the patterns of bar iron that are required. These may vary from 2 inches square to less than one sixth of an inch.

Beneath the cylinders there is usually formed an oblong fosse, into which the scoriæ and the scales fall when the iron is compressed. The sides of this fosse, constructed of stone, are founded on a body of solid masonry, capable of supporting the enormous load of the cylinders. Beams of wood form in some measure the sides of this pit, to which cylinders may be made fast, by securing them with screws and bolts. Massive bars of cast iron are found, however, to answer still better, not only because the uprights and bearers may be more solidly fixed to them, but because the basement of heavy metal is more difficult to shatter or displace, an accident which happens frequently to the wooden beams. A rill of water is supplied by a pipe to each pair of cylinders, to hinder them from getting hot; as also to prevent the hot iron from adhering to the cylinder, by cooling its surface, and perhaps producing on it a slight degree of oxydizement.

The shafts are one foot in diameter for the hammer and the roughing rolls; and six inches where they communicate motion to the cylinders destined to draw the iron into bars.

The *roughing rolls* are employed either to work out the lump or ball immediately after it leaves the puddling furnace, as in the Welsh forges, or only to draw out the piece, after it has been shaped under the hammer, as is practised in most of the Stafford-shire establishments. These roughing cylinders are generally 7 feet long, including the trunnions, or 5 feet between the bearers, and 18 inches diameter; and weigh in the whole from 4 to 4½ tons. They contain from 5 to 7 grooves, commonly of an elliptical form, one smaller than another in regular progression, as is seen in *fig.* 597. The small axis of each ellipse, as formed by the union of the upper and under grooves, is always placed in the vertical direction, and is equal to the great axis, or horizontal axis of the succeeding groove; so that in transferring the bar from one groove to another, it must receive a quarter of a revolution, whereby the iron gets elongated in every direction. Sometimes the roughing rolls serve as preparatory cylinders, in which case they bear towards one extremity rectangular grooves, as the figure exhibits. Several of these large grooves are bestudded with small asperities analogous to the teeth of files, for biting the lump of iron, and preventing its sliding. On a level with the under side of the grooves of the lower cylinder, there is a plate of cast iron with notches in its edge adapted to the grooves. This piece, called the apron, rests on iron rods, and serves to support the balls and bars exposed to the action of the rollers, and to receive the fragments of ill-welded metal, which fall off during the drawing. The *housing frames* in which the rollers are supported and revolve, are made of great strength. Their height is 5 feet; their thickness is 1 foot in the side perpendicular to the axis of the cylinders, and 10 inches in the other. Each pair of bearers is connected at their upper ends by two iron rods, on which the workmen rest their tongs or pincers for passing the lump or bar from one side of the cylinders to the other.

The cods or bushes are each composed of two pieces; the one of hard brass, which presents a cylindrical notch, is framed into the other which is made of cast iron, as is clearly seen in *fig.* 597.

The iron bar delivered from the square grooves, is cut by the shears into short lengths, which are collected in a bundle in order to be welded together. When this bundle of bars has become hot enough in the furnace, it is conveyed to the rollers; which differ in their arrangement according as they are meant to draw iron from a large or small piece. The first, *fig.* 597, possess both elliptical and rectangular grooves; are 1 foot in diameter and 3 feet long between the bearers. The bar is not finished under these cylinders, but is transferred to another pair, whose grooves have the dimensions proper for the bar, with a round, triangular, rectangular, or fillet form. The triangular grooves made use of for square iron, have for their profile an isosceles triangle, slightly obtuse, so that the space left by the two grooves together may be a rhombus, differing little from a square, and whose smaller diagonal is vertical. When the bar is to be passed successively through several grooves of this kind, the larger or horizontal diagonal of each following groove is made equal to the smaller or upright of the preceding one, whereby the iron must be turned one fourth round at each successive draught, and thus receive pressure in opposite directions. Indeed, the bar is often turned in succession through the triangular and rectangular grooves, that its fibres may be more accurately worked together. The decrement in the capacity of the grooves follows the proportion of 15 to 11.

When it is intended to reduce the iron to a small rod, the cylinders have such a diameter, that three may be set in the same housing frame. The lower and middle cylinders are employed as roughing rollers, while the upper and middle ones are made to draw out the rod. When a rod or bar is to be drawn with a channel or gutter in its face, the grooves of the rollers are suitably formed.

To draw out square rods of a very small size, as nail-rods, a system of small rollers is employed, called *slitters*. Their ridges are sharp-edged, and enter into the opposite grooves 2½ inches deep; so that the flat bar in passing between such rollers is instantaneously divided into several slips. For this purpose the rollers represented in *fig.* 598 may be

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put on and removed from the shaft at pleasure.

The velocity of the cylinders varies with their dimensions. In one work, cylinders for drawing out iron of from one third to two thirds of an inch thick, make 140 revolutions per minute; while those for iron of from two thirds of an inch to 3 inches, make only 66. In another work, the cylinders for two inch iron, make 95 revolutions per minute; those for iron from two thirds of an inch to an inch and a third, make 128; and those for bars from one third to two thirds of an inch, 150. The *roughing rollers* move with only one third the velocity of the drawing cylinders.

The shingling and plate-rolling mill is represented in *fig.* 597. The shingling mill, for converting the blooms from the balling furnace into bars, consists of two sets of grooved cylinders, the first being called *puddling rolls* or *roughing rolls;* the second are for reducing or drawing the iron into mill-bars, and are called simply *rolls.*

a, a, a, a, are the powerful uprights or standards called *housing frames*, of cast iron, in which the gudgeons of the rolls are set to revolve; *b, b, b, b,* are bolt rods for binding these frames together at top and bottom; *c,* are the roughing rolls, having each a series of triangular grooves, such that between those of the upper and under cylinder, rectangular concavities are formed in the circumference with slightly sloping sides. The end groove to the right of *c,* should be channelled like a rough file, in order to take the better hold of the blooms, or to bite the metal, as the workmen say; and give it the preparatory elongation for entering into and passing through the remaining grooves till it comes to the square ones, where it becomes a mill-bar. *d, d,* are the smooth cylinders, hardened upon the surface, or *chilled* as it is called, by being cast in iron moulds, for rolling iron into plates or hoops. *e, e, e, e,* are strong screws with rectangular threads, which work by means of a wrench or key, into the nuts *e' e' e' e',* fixed in the standards; they serve to regulate the height of the plummer blocks or bearers of the gudgeons, and thereby the distance between the upper and under cylinders. *f* is a junction shaft; *t, g, g,* are solid coupling boxes, which embrace the two separate ends of the shafts, and make them turn together. *h, h,* are junction pinions, whereby motion is communicated from the driving shaft *f,* through the under pinion to the upper one, and thus to both upper and under rolls at once. *i, i,* are the pinion standards in which their shafts run; they are smaller than the uprights of the rolls. *k, k,* are screws for fastening the head pieces *l* to the top of the pinion standards. All the standards are provided with sole plates *m,*

whereby they are screwed to the foundation beams *s*, of wood or preferably iron, as shown by dotted lines; *o o* are the binding screw bolts. Each pair of rolls at work is kept cool by a small stream of water let down upon it from a pipe and stop-cock.

In the cylinder drawing, the workman who holds the ball in tongs, passes it into the first of the elliptical grooves; and a second workman on the other side of the cylinders, receives this lump, and hands it over to the first, who re-passes it between the rollers, after bringing them somewhat closer to each other, by giving a turn to the adjusting pressure screws. After the lump has passed five or six times through the same groove, it has got an elliptical form, and is called in England a *bloom*. It is next passed through a second groove of less size, which stretches the iron bar. In this state it is subjected to a second pair of cylinders, by which the iron is drawn into flat bars, 4 inches broad and half an inch thick. Fragments of the ball or bloom fall round about the cylinders; which are afterwards added to the puddling charge. In a minute and a half, the rude lump is transformed into bars, with a neatness and rapidity which the inexperienced eye can hardly follow. A steam engine of thirty-horse power can *rough down* in a week, 200 tons of coarse iron.

This iron, called mill-bar iron, is however of too inferior a quality to be employed in any machinery; and it is subjected to another operation, which consists in welding several pieces together, and working them into a mass of the desired quality. The iron bars, while still hot, are cut by the shears into a length proportional to the size of iron bar that is wanted; and four rows of these are usually laid over each other into a heap or pile, which is placed in the *re-heating* furnace above described, and exposed to a free circulation of heat; one pile being set crosswise over another. In a half or three quarters of an hour, the iron is hot enough, and the pieces now sticking together, are carried in successive piles to the bar-drawing cylinders, to be converted into strong bars, which are reckoned of middle quality. When a very tough iron is wanted, as for anchors, another welding and rolling must be given. In the re-heating ovens, the loss is from 8 to 10 per cent. on the large bar iron, and from 10 to 12 in smaller work. A ton of iron consumes in this process about 150 lbs. of coals.

It is thought by many that a purer iron is obtained by subjecting the balls as they come out of the puddling furnace, to the action of the hammer at first, than to the roughing rollers; and that by the latter process vitrified specks remain in the metal, which the hammer expels. Hence, in some works, the balls are first worked under the forge-hammer; and these *stampings* being afterwards heated in the form of pies or cakes piled over each other, are passed through the roughing rollers.

Having given ample details concerning the manufacturing processes used in England for making cast iron, it may be proper to subjoin a few observations upon its chemical constitution. It has been generally believed and taught that the dark gray cast iron, No. 1 or No. 2, contains more carbon than the white cast iron; and that the superior quality of the former in tenacity and softness, is to be ascribed to that excess. But the distinguished German metallurgist, M. Karsten, in his instructive volume, "Handbuch der Eisenhüttenkunde," or manual of the art of smelting iron ores, has proved, on the contrary, that the white cast iron contains most charcoal; that this substance exists in it in a state of combination with the whole body of the iron; that the foliated or lamellar white cast iron contains as much carbon as iron can absorb in the liquid state; and that this constitutes a compound of 4 atoms of iron combined with 1 of charcoal, or 112+6; or 5¼ per cent.; whereas the dark gray cast iron contains generally from 3 to 4 per cent., in the state of plumbago merely dispersed through the metal. He has further confirmed his opinion, by causing the white variety to pass into the gray, and reciprocally. Thus, dark gray cast metal melted and suddenly cooled, gives a silvery white metal, hard and brittle. On the other hand, when the white cast iron is cooled very slowly after fusion, the condition of the carbon in it changes, and a dark gray cast iron is obtained. These phenomena show that the graphite or plumbago, which requires a high temperature for its formation, cannot be produced but by a slow cooling, which allows the carbon to agglomerate itself in the iron in the state of graphite; while under a rapid congelation, the carbon remains dissolved in the mass, and produces a white metal. Hence we may understand how each successive fusion of dark gray iron hardens and whitens it, though in contact with coke, by completing that chemical dissolution of the carbon on which the white state depends.

In the manufacture of the blackest No. 1 cast iron, it sometimes happens that a considerable quantity of a glistening carburet of iron appears, floating on the top of the metal as it is run out into the sand-moulds. This substance is called *kish* by the English workmen; and it affords a sure test of the good state of the furnace and quality of the iron.

The most remarkable fact relative to the smelting of cast iron, is the difference of product between the workings of the summer and the winter season, though all the materials and machinery be the same. In fact, no cold-blast furnace will carry so great a burden

in summer as in winter, that is, afford so great a product of metal, or bear so great a charge of ore with the same quantity of coke. This difference is undoubtedly due to the dilated and humid state of the atmosphere in the warm season. A very competent judge of this matter, states the diminution in summer at from one fifth to one seventh, independently of deterioration of quality.

Some of the foreign irons, particularly certain Swedish and Russian bars, are imported into Great Britain in large quantities, and at prices much greater than those of the English bars, and therefore the modes of manufacturing such excellent metal deserve examination. All the best English cast steel, indeed, is made from the hoop L iron from Dannemora, in Sweden.

The processes pursued in the smelting works of the Continent have frequently in view to obtain from the ore malleable iron directly, in a pure or nearly pure state. The furnaces used for this purpose are of two kinds, called in French, 1. *Feux de Loupes*, or *Forges Catalanes*; and 2. *Fourneaux à pièce*, or *Forges Allemandes*.

In the Catalan, or French method, the ore previously roasted in a kiln is afterwards strongly torrefied in the forge before the smelting begins; operations which follow in immediate succession. Ores treated in this way should be very fusible and very rich; such as black oxyde of iron, hematites, and certain spathose iron ores. From 100 parts of ore, 50 of metallic iron have been procured, but the average product is 35. The furnaces employed are rectangular hearths, *figs.* 599, and 600, the water-blowing
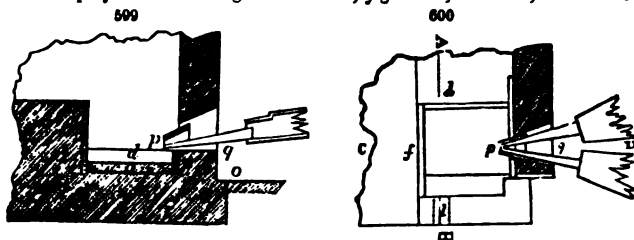
machine being employed to give the blast. See METALLURGY. There are three varieties of this forge; the Catalan, the Navarrese, and the Biscayan. The dimensions of the first, the one most generally employed, are as follows: 21 inches long, in the direction *p f, fig.* 600; 18½ broad, at the bottom of the hearth or *creuset*, in the line A B; and 17 inches deep, *fig.* 599. The tuyère, *q p*, is placed 9½ inches above the bottom, so that its axis is directed towards the opposite side, about 2 inches above the bottom. But it must be moveable, as its inclination needs to be changed, according to the stage of the operation, or the quantity of the ores. It is often raised or lowered with pellets of clay; and even with a graduated circle, for the workmen make a great mystery of this matter. The hearth is lined with a layer of *brasque* (loam and charcoal dust worked together), and the ore after being roasted is sifted; the small powder being set aside to be used in the course of the operation. The ore is piled up on the side opposite to the blast in a sharp saddle ridge, and it occupies one third of the furnace. In the remaining space of two thirds, the charcoal is put. To solidify the small ore on the hearth, it is covered with moist cinders mixed with clay.

The fire is urged with moderation during the first two hours, the workman being continually employed in pressing down more charcoal as the former supply burns away, so as to keep the space full, and prevent the ore from crumbling down. By a blast so tempered at the beginning, the ore gets well calcined, and partially reduced in the way of cementation. But after two hours, the full force of the air is given; at which period the fusion ought to commence. It is easy to see whether the torrefaction be sufficiently advanced, by the aspect of the flame, as well as of the ore, which becomes spongy or cavernous; and the workman now completes the fusion, by detaching the pieces of ore from the bottom, and placing them in front of the tuyère. When the fine siftings are afterwards thrown upon the top, they must be watered, to prevent their being blown away, and to keep them evenly spread over the whole surface of the light fuel. They increase the quantity of the products, and give a proper fusibility to the scoriæ. When the scoriæ are viscid, the quantity of siftings must be diminished; but if thin, they must be increased. The excess of slag is allowed to run off by the *chio* or floss hole. The process lasts from five to six hours, after which the pasty mass is taken out, and placed under a hammer to be cut into lumps, which are afterwards forged into bars.

Each mass presents a mixed variety of iron and steel; in proportions which may be modified at pleasure; for by using much of the siftings, and making the tuyère dip towards the sole of the hearth, iron is the chief product; but if the operation be con-

ducted slowly, with a small quantity of siftings, and an upraised tuyère, the quantity of steel is more considerable. This primitive process is favorably spoken of by M. Brongniart. The weight of the lump of metal varies from 200 to 400 pounds. As the consumption of charcoal is very great, amounting in the Palatinate or Rheinkreis to seven times the weight of iron obtained, though in the Pyrenees it is only thrice, the Catalan forge can be profitably employed only where wood is exceedingly cheap and abundant.

The *Fourneaux à pièce* of the French, or *Stuck-ofen* of the Germans, resembles *fig.* 313 (Copper); the tuyère (not shown there) having a dip towards the bottom of the hearth, where the smelted matter collects. When the operation is finished, that is, at least once in every 24 hours, one of the sides of the hearth must be demolished, to take out the pasty mass of iron, more or less pure. This furnace holds a middle place in the treatment of iron, between the Catalan forge and the cast-iron *floss-ofen*, or high-blast furnaces. The *stuck-ofen* are from 10 to 15 feet high, and about 3 feet in diameter at the hearth. Most usually there is only one aperture for the tuyère and for working; with a small one for the escape of the slag; on which account, the bellows are removed to make way for the lifting out of the lump of metal, which is done through an opening left on a level with the sole, temporarily closed with bricks and potters' clay, while the furnace is in action.

This outlet being closed, and the furnace filled with charcoal, fire is kindled at the bottom. Whenever the whole is in combustion, the roasted ore is introduced at the top in alternate charges with charcoal, till the proper quantity has been introduced. The ore falls down; and whenever it comes opposite to the tuyère the slag begins to flow, and the iron drops down and collects at the bottom of the hearth into the mass or *stuck*; and in proportion as this mass increases, the *floss-hole* for the slag and the tuyère is raised higher. When the quantity of iron accumulated in the hearth is judged to be sufficient, the bellows are stopped, the scoriæ are raked off, the little brick wall is taken down, and the mass of iron is removed by rakes and tongs. This mass is then flattened under the hammer, into a cake from 3 to 4 inches thick, and is cut into two lumps, which are submitted to a new operation; where it is treated in a peculiar refinery, lined with charcoal *brasque*, and exposed to a nearly horizontal blast. The above mass, seized in the jaws of a powerful tongs, is heated before the tuyère; a portion of the metal flows down to the bottom of the hearth, loses its carbon in a bath of rich slags or fused oxydes, and forms thereby a mass of iron thoroughly refined. The portion that remains in the tongs furnishes steel, which is drawn out into bars.

This process is employed in Carniola for smelting a granular oxyde of iron. The mass or *stuck* amounts to from 15 to 20 hundred weight, after each operation of 24 hours. Eight strong men are required to lift it out, and to carry it under a large hammer, where it is cut into pieces of about 1 cwt. each. These are afterwards refined and drawn into bars as above described. These furnaces are now almost generally abandoned on the Continent, in favor of *charcoal high* or *blast furnaces*.

Fig. 313 represents a *shachtofen* (but without the tuyère, which may be supposed to be in the usual place), and is, like all the continental *Hauts Fourneaux*, remarkable for the excessive thickness of its masonry. The charge is put in at the throat, near the summit of the octagonal or square concavity, for they are made of both forms. At the bottom of the hearth there is a dam-stone with its plate, for permitting the overflow of the slag, while it confines the subjacent fluid metal; as well as a tymp-stone with its plate, which forms the key to the front of the hearth; the boshes are a wide funnel, almost flat, to obstruct the easy descent of the charges, whereby the smelting with charcoal would proceed too rapidly. The bottom of the hearth is constructed of two large stones, and the hinder part of one great stone, called in German, *rückstein* (black stone), which the French have corrupted into *rustine*. In other countries of the Continent, the boshes are frequently a good deal more tapered downwards, and the hearth is larger than here represented. The refractory nature of the Hartz iron ores is the reason assigned for this peculiarity.

In Sweden there are blast-furnaces, *schachtofen*, 35 feet in height, measured from the boshes above the line of the hearth, or *creuset*. Their cavity has the form of an elongated ellipse, whose small diameter is 8 feet across, at a height of 14 feet above the bottom of the hearth; hence, at this part, the interior space constitutes a belly, corresponding with the upper part of the boshes. In other respects, the details of the construction of the Swedish furnaces resemble the one figured above. Marcher relates that a furnace of that kind, whose height was only 30 feet, in which brown hydrate of iron (*hematite*) was smelted, yielded 47 *per cent.* in cast-iron, at the rate of 5 hundred weight a day, or 36 hundred weight one week after another; and that in the production of 100 pounds of cast-iron, 130 pounds of charcoal were consumed. That furnace was worked with forge bellows, mounted with leather.

The decarburation of cast-iron is merely a restoration of the carbon to the surface, in tracing inversely the same progressive steps as had carried it into the interior during the smelting of the ore. The oxygen of the air, acting first at the surface of the cast metal, upon the carbon which it finds there, burns it: fresh charcoal, oozing from the interior, comes then to occupy the place of what had been dissipated; till, finally, the whole carbon is transferred from the centre to the surface, and is there converted into either carbonic acid gas, or oxyde of carbon; for no direct experiment has hitherto proved which of these is the precise product of this combustion.

This diffusibility of carbon through the whole mass of iron constitutes a movement by means of which cast-iron may be refined even without undergoing fusion, as is proved by a multitude of phenomena. Every workman has observed that steel loses a portion of its steely properties every time it is heated in contact with air.

On the above principle, cast-iron may be refined at one operation. Three kinds of iron are susceptible of this continuous process:—1. The speckled cast-iron, which contains such a proportion of oxygen and carbon as with the oxygen of the air and the carbon of the fuel may produce sufficient and complete saturation, but nothing in excess. 2. The dark gray cast-iron. 3. The white cast-iron. The nature of the crude metal requires variations both in the forms of the furnaces, and in the manipulations.

Indeed, malleable iron may be obtained directly from the ores by one fusion. This mode of working is practised in the Pyrenees to a considerable extent. All the ores of iron are not adapted for this operation. Those in which the metallic oxyde is mixed with much earthy matter, do not answer well; but those composed of the pure black oxyd, red oxyde, and carbonate, succeed much better. To extract the metal from such ores, it is sufficient to expose them to a high temperature, in contact either with charcoal, or with carbonaceous gases; the metallic oxyde is speedily reduced. But when several earths are present, these tend continually, during the vitrification which they suffer, to retain in their vitreous mass the unreduced oxyde of iron. Were such earthy ores, as our ironstones, to be put into the low furnaces called Catalan, through which the charge pass with great rapidity, and in which the contact with the fuel is merely momentary, there would be found in the crucible or hearth merely a rich metallic glass, instead of a lump of metal.

In smelting and refining by a continuous operation, three different stages may be distinguished: 1. The roasting of the ore to expel the sulphur, which would be less easily separated afterwards. The roasting dissipates likewise the water, the carbonic acid, and any other volatile substances which the minerals may contain. 2. The deoxydizement and reduction to metal by exposure to charcoal or carbureted vapors. 3. The melting, agglutination, and refining of the metal to fit it for the heavy hammers where it gets nerve. There are several forges in which these three operations seem to be confounded into a single one, because, although still successive, they are practised at one single heating without interruption. In other forges, the processes are performed separately, or an interval elapses between each stage of the work. Three systems of this kind are known to exist:—1. The Corsican method; 2. The Catalan with wood charcoal; and 3. The Catalan with coke.

The furnaces of Corsica are a kind of semicircular basins, 18 inches in diameter, and 6 inches deep. These are excavated in an area, or a small elevation of masonry, 8 or 10 feet long by 5 or 6 broad, and covered in with a chimney. This area is quite similar to that of the ordinary hearths of our blast-furnaces.

The tuyère stands 5 or 6 inches above the basin, and has a slight inclination downwards. In Corsica, and the whole portion of Italy adjoining the Mediterranean shores, the iron ore is an oxyde similar to the specular ore of the Isle of Elba. This ore contains a little water, some carbonic acid, occasionally pyrites, but in small quantity. Before deoxydizing the ore, it is requisite to expel the water and carbonic acid combined with the oxyde, as well as the sulphur of the pyrites.

The operations of roasting, reduction, fusion, and agglutination, are executed in the same furnace. These are indeed divided into two stages, but the one is a continuation of the other. In the first, the two primary operations are performed at once;—the reduction of a portion of the roasted ore is begun at the same time that a portion of the raw ore is roasted: these two substances are afterwards separated. In the second stage, the deoxydizement of the metal is continued, which had begun in the preceding stage; it is then melted and agglutinated, so as to form a ball to be submitted to the forge-hammer.

The roasted pieces are broken down to the size of nuts, to make the reduction of the metal easier. In executing the first step, the basin and area of the furnace must be lined with a *brasque* of charcoal dust, 3, 4, or even 5 inches thick: over this *brasque* a mound is raised with lumps of charcoal, very hard, and 4 or 5 inches high. A semicircle is formed round the tuyère, the inner radius of which is 5 or 6 inches. This mass of charcoal is next surrounded with another pile of the roasted and broken ores, which

must be covered with charcoal dust. The whole is sustained with large blocks of the raw ore, which form externally a third wall.

These three piles of charcoal, with roasted and unroasted ore, are raised in three successive beds, each 7 inches thick : they are separated from each other by a layer of charcoal dust of about an inch, which makes the whole 24 inches high. This is afterwards covered over with a thick coat of pounded charcoal.

The blocks of raw ore which compose the outward wall form a slope ; the larger and stronger pieces are at the bottom, and the smaller in the upper part. The large blocks are sunk very firmly into the charcoal dust, to enable them better to resist the pressure from within.

On the bottom of the semicircular well formed within the charcoal lumps, kindled pieces are thrown, and over these, pieces of black charcoal; after which the blast of a water-blowing machine (trompe) is given. The fire is kept up by constantly throwing charcoal into the central well. At the beginning of the operation it is thrust down with wooden rods, lest it should affect the building ; but when the heat becomes too intense for the workmen to come so near the hearth, a long iron rake is employed for the purpose. At the end of about 3 hours, the two processes of roasting and reduction are commonly finished : then the raw ore no longer exhales any fumes, and the roasted ore, being softened, unites into lumps more or less coherent.

The workman now removes the blocks of roasted ore which form the outer casing, rolls them to the spot where they are to be broken into small pieces, and pulls down the *brasque* (small charcoal) which surrounds the mass of reduced ore.

The second operation is executed by cleaning the basin, removing the slags, covering the basin anew with 2 or 3 brasques (coats of pounded charcoal), and piling up to the right and the left, two heaps of charcoal dust. Into the interval between these conical piles two or three baskets of charcoal are cast, and on its top some cakes of the reduced crude metal being laid, the blast is resumed. The cakes, as they heat, undergo a sort of liquation, or sweating, by the action of the earthy glasses on the unreduced black oxyde present. Very fusible slags flow down through the mass ; and the iron, reduced and melted, passes finally through the coals, and falls into the slag basin below. To the first parcel of cakes, others are added in succession. In proportion as the slags proceeding from these run down, and the melted iron falls to the bottom, the thin slag is run off by an upper overflow or *chio* hole, and the reduced iron kept by the heat in the pasty condition, remains in the basin : all its parts get agglutinated, forming a soft mass, which is removed by means of a hooked pole in order to be forged. Each lump or *bloom* of malleable iron requires 3 hours and a half for its production.

The iron obtained by this process is in general soft, very malleable, and but little steely. In Corsica four workmen are employed at one forge. The produce of their labor is only about 4 cwts. of iron from 10 cwts. of ore and 20 of charcoal, mingled with wood of beech and chestnut. Though their ore contains on an average 65 per cent. of iron, only about 40 parts are extracted ; evincing a prodigious waste, which remains in the slags.

The difference between the Corsican and the Catalonian methods consists in the latter roasting the ore at a distinct operation, and employing a second one in the reduction, agglutination, and refining of the metal. In the Catalonian forges, 100 pounds of iron are obtained from 300 pounds of ore and 310 pounds of charcoal ; being a produce of only 33 per cent. It may be concluded that there is a notable loss, since the sparry iron ores, which are those principally smelted, contain on an average from 54 to 56 per cent. of iron. The same ores, smelted in the ordinary blast furnace, produce about 45 per cent. of cast iron.

On the Continent, iron is frequently refined from the cast metal of the blast furnaces by three operations, in three different ways. In one, the pig being melted, with aspersion of water, a cake is obtained, which is again melted in order to form a second cake. This being treated in the refinery fire, is then worked into a *bloom*. In another system, the pig iron is melted and cast into plates : these are melted anew in order to obtain crude balls, which are finally worked into blooms. In a third mode of manufacture, the pig-iron is melted and cast into plates, which are roasted, and then strongly heated, to form a bloom.

The French fusible ores, such as the silicates of iron, are very apt to smelt into white cast iron. An excess of fluxes, light charcoals, too strong a blast, produce the same results. A surcharge of ores which deranges the furnace and affords impure slags mixed with much iron, too rapid a slope in the boshes, too low a degree of heat, and too great condensation of the materials in the upper part of the furnace ; all tend also to produce a white cast iron. In its state of perfection, white cast iron has a silver color, and a bright metallic lustre. It is employed frequently in Germany for the manufacture of steel, and is then called *steel floss*, or *lamellar floss*, a title which it still retains, though it be hardly silver white, and have ceased to be foliated. When its color takes a bluish-

and a chisel into 4 or 6 pieces, which are reheated, one after another, in the same refinery fire, in order to be forged into bars, while another pig of cast iron is laid in its place, to prepare for the formation of a new bloom. The above process is called by the Germans *klump-frischen*, or lump-refining. It differs from the *durch-brech-frischen*, because in the latter, the lump is not turned over in mass, but is broken, and exposed in separate pieces successively to the refining power of the blast near the tuyère. The French call this *affinage par portions*; it is much lighter work than the other.

The quality of the iron is tried in various ways; as first, by raising a bar by one end, with the two hands over one's head, and bringing it forcibly down to strike across a narrow anvil at its centre of percussion, or one third from the other extremity of the bar; after which it may be bent backwards and forwards at the place of percussion several times; 2. a heavy bar may be laid obliquely over props near its end, and struck strongly with a hammer with a narrow pane, so as to curve it in opposite directions; or while heated to redness, they may be kneed backwards and forwards at the same spot, on the edge of the anvil. This is a severe trial, which the hoop L, Swedish iron, bears surprisingly, emitting as it is hammered, a phosphoric odor, peculiar to it and to the bar iron of Ulverstone, which also resembles it, in furnishing a good steel. The forging of a horse-shoe is reckoned a good criterion of the quality of iron. Its freedom from flaws is detected by the above modes; and its linear strength may be determined by suspending a scale to the lower end of a hard-drawn wire, of a given size, and adding weights till the wire breaks. The treatises of Barlow and Tredgold may be consulted with advantage on the methods of proving the strength of different kinds of iron, in a great variety of circumstances.

Steel of cementation, or blistered steel and cast steel, are treated under the article STEEL. But since in the conversion of cast iron into wrought iron, by a very slight difference in the manipulations, a species of steel may be produced called *natural steel*, I shall describe this process here.

Fig. 603 is a view of the celebrated steel iron works, called Königshütte, (*king's-forge*), in Upper Silesia, being one of the best arranged in Germany, for smelting iron ore by
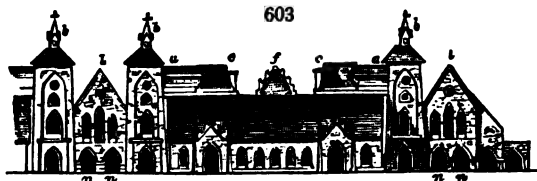
means of coke. The front shown here is about 400 English feet long. *a a* are two blast furnaces. A third blast furnace, all like the English, is situated to the left of one of the towers *b*. *b b* are the charging towers, into which the ore is raised by machinery from the level of the store-houses *l l*, up to the mouth of the furnaces *a a*; *c c* point to the positions of the boilers of the two steam engines, which drive two cylinder bellows at *f*. *n n n n* are arched cellars placed below the store-houses *l l*, for containing materials and tools necessary for the establishment.

Figs. 599, 604, are vertical sections of the forge of Königshütte, for making natural steel; *fig.* 599 being drawn in the line A B of the plan, *fig.* 600. *a* is the bottom of the hearth, consisting of a fire-proof gritstone; *b* is a space filled with small charcoal, damped with water, under which, at *n*, in *fig.* 604, is a bed of well rammed clay; *d* is a plate of cast iron, which lines the side of the hearth called ruckstein (backstone) in German, and corrupted by the French into *rustine*; *f* is the plate of the counter-blast; *g* the plate of the side of the tuyère; behind, upon the face *d*, the fire-place or hearth is only 5½ inches deep; in front as well as upon the lateral faces, it is 18 inches deep. By means of a mound made of dry charcoal, the posterior face *d* is raised to the height of the face *f*. *i*, *fig.* 600, is the floss-hole, by which the slags are run off from the hearth during the working, and through which, by removing some bricks, the lump of steel is taken out when finished.
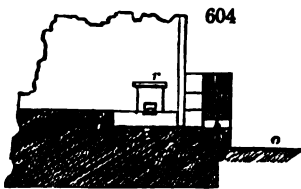
k l m are pieces of cast iron, for confining the fire in front, that is, towards the side where the workman stands; *o* is the level of the floor of the works; *p* a copper tuyère; it is situated 4½ inches above the bottom *a*, slopes 5 degrees towards it, and advances 4 inches into the hearth or fire-place, where it presents an orifice, one half inch in horizontal length, and one inch up and down; *q* the nose pipes of two bellows, like those represented

in *fig.* 602, and under SILVER; the round orifice of each of them within the tuyère being one inch in diameter. *r* is the lintel or top arch of the tuyère, beneath which is seen the cross section of the pig of cast iron under operation.

For the production of natural steel, a white cast iron is preferred, which contains little carbon, which does not flow thin, and which being cemented *over or above the wind*, falls down at once through the blast to the bottom of the hearth in the state of steel. With this view, a very flat fire is used; and should the metal run too fluid, some malleable lumps are introduced to give the mass a thicker pasty consistence.

If the natural steel be supposed to contain too little carbon, which is a very rare case, the metal bath covered with its cinder slag, is diligently stirred with a wooden pole, or it may receive a little of the more highly carbureted iron. If it contains the right dose of carbon, the earthy and other foreign matters are made progressively to sweat out, into the supernatant slag. When the mass is found by the trial of a sample to be completely converted, and has acquired the requisite stiffness, it is lifted out of the furnace, by the opening in front, subjected to the forge hammer, and drawn into bars. In Sweden, the cast iron pigs are heated to a cherry-red, and in this state broken to pieces under the hammer, before they are exposed in the steel furnace. These natural steels are much employed on the Continent in making agricultural implements, on account of their cheapness. The natural steel of Styria is regarded as a very good article.

Wootz is a natural steel prepared from a black ore of iron in Hindostan, by a process analogous to that of the Catalan hearth, but still simpler. It seems to contain a minute portion of the combustible bases of alumina and silica, to which its peculiar hardness when tempered may possibly be ascribed. It is remarkable for the property of assuming a damask surface, by the action of dilute sulphuric acid, after it has been forged and polished. See DAMASCUS and STEEL.

Fig. 605 is the German forge-hammer; to the left of 1, is the axis of the rotatory

cam, 2, 3, consisting of 8 sides, each formed of a strong broad bar of cast iron, which are joined together to make the octagon wheel. 4, 5, 6, are cast iron binding rings or hoops, made fast by wooden wedges. *b, b,* are standards of the frame-work *e, l, m,* in which the helve of the forge-hammer has its fulcrum near *u. h,* the sole part of the frame. Another cast iron base or sole is seen at *m.* a is a strong stay, to strengthen the frame-work. At *r* two parallel hammers are placed, with cast-iron heads and wooden helves. *s* is the anvil, a very massive piece of cast iron. *t* is the end of a vibrating beam, for throwing back the hammer from it forcibly by recoil. *x y* is the outline of the water-wheel which drives the whole. The cams or tappets are shown mounted upon the wheel 6, *g,* 6.

Analysis of irons.—Oxydized substances cannot exist in metallic iron, and the foreign substances it does contain are present in such small quantities, that it is somewhat difficult to determine their amount. The most intricate point is, the proportion of carbon. The free carbon, which is present only in gray cast iron, may, indeed, be determined nearly, for most of it remains after solution of the metal in acids. The combined charcoal, however, changes by the action of muriatic acid into gas and oil; sulphuric acid also occasions a great loss of carbon, and nitric acid dissipates it almost entirely. Either nitre or chloride of silver may be employed to ascertain the amount of carbon; but when the iron contains chromium and much phosphorus, the determination of the carbon is attended with many difficulties.

The quantity of sulphur is always so small, that it can scarcely be ascertained by the weight of the precipitate of sulphate of barytes from the solution of the iron in nitro-muriatic acid. The iron should be dissolved in muriatic acid; and the hydrogen, as it escapes charged with the sulphur, should be passed through an acidulous solution of acetate of lead. The weight of the precipitated sulphuret shows the amount of sulphur, allowing 13·45 of the latter for 100 of the former. In this experiment the metal should be slowly acted upon by the acid. Cast iron takes from 10 to 15 days to dissolve, steel from 8 to 10, and malleable iron 4 days. The residuum of a black color does not contain a trace of sulphur.

Phosphorus and chromium are determined in the following way. The iron must be dissolved in nitro-muriatic acid, to oxygenate those two bodies. The solution must be evaporated cautiously to dryness in porcelain capsules, and the saline residuum heated

to redness. A little chloride of iron is volatilized, and the remainder resembles the red-brown oxyde. This must be mixed with thrice its weight of carbonate of potash, and fused in a platinum crucible; the quantity of iron being from 40 to 50 grains at most.

The mixture, after being acted upon by boiling water, is to be left to settle, to allow the oxyde to be deposited, for it is so fine as to pass through a filter. If the iron contained manganese, this would be found *at first* in the alkaline solution; but manganese spontaneously separates by exposure to the air. The alkaline liquor must be supersaturated with muriatic acid, and evaporated to dryness. The liquor acidulated, and deprived of its silica by filtration, is to be supersaturated with ammonia; when the alumina will precipitate in the state of a subphosphate. When the liquor is now supersaturated with acetic acid, and then treated with acetate of lead, a precipitate of phosphate of lead almost always falls. There is hardly a bit of iron to be found which does not contain phosphorus. The slightest trace of chrome is detected by the yellow color of the lead precipitate; if this be white there is none of the coloring metal present.

100 parts of the precipitated phosphate of lead contain, after calcination, 19·4 parts of phosphoric acid. The precipitate should be previously washed with acetic acid, and then with water. These 19·4 parts contain 8·525 parts of phosphorus.

Cast iron sometimes contains calcium and barium, which may be detected by their well-known reagents, oxalate of ammonia, and sulphuric acid. In malleable iron they are seldom or never present.

The charcoal found in the residuum of the nitro-muriatic solution is to be burned away under a muffle. The solution itself contains along with the oxyde of iron, protoxyde of manganese, and other oxydes, as well as the earths, and the phosphoric and arsenic acids. Tartaric acid is to be added to it, till no precipitate be formed by supersaturation with caustic ammonia. The ammoniacal liquor must be treated with hydrosulphuret of ammonia as long as it is clouded, then thrown upon a filter. The precipitate is usually very voluminous, and must be well washed. The liquor which passes through is to be saturated with muriatic acid, to decompose all the sulphurets.

The solution still contains all the earths and the oxyde of titanium, besides the phosphoric acid. It is to be evaporated to dryness, whereby the ammonia is expelled, and the carbonaceous residuum must be burned under a muffle. If the iron contains much phosphorus, the ashes are strongly agglutinated. They are to be fused as already described along with carbonate of potash, and the mass is to be treated with boiling water. The residuum may be examined for silica, lime, barytes, and oxyde of titanium. Muriatic acid being digested on it, then evaporated to dryness, and the residuum treated with water, will leave the silica. Caustic ammonia, poured into the solution, will separate the alumina, if any be present, and the oxyde of titanium; but the former almost never occurs.

Manganese is best sought for by a distinct operation. The iron must be dissolved at the heat of boiling water, in nitro-muriatic acid; and the solution, when very cold, is to be treated with small successive doses of solution of carbonate of ammonia. If the iron has been oxydized to a maximum, and if the liquor has been sufficiently acid, and diluted with water, it will retain the whole of the manganese. This process is as good as that by succinate of ammonia, which requires many precautions.

The liquor is often tinged yellow by carbon, after it has ceased to contain a single trace of iron oxyde. As soon as litmus paper begins to be blued by carbonate of ammonia, we should stop adding it; immediately throw the whole upon a filter, and wash continuously with cold water. What passes through is to be neutralized with muriatic acid, and concentrated by evaporation. It may contain, besides manganese, some lime or barytes. It should therefore be precipitated with hydro-sulphuret of ammonia, the hydrosulphuret of manganese should be collected, dissolved in strong muriatic acid, filtered, and treated, at a boiling heat, with carbonate of potash. The precipitate, well washed and calcined, contains, in 100 parts, 72·75 parts of metallic manganese.

The copper, arsenic, lead, tin, bismuth, antimony, or silver, are best separated by a stream of sulphureted hydrogen gas passed through the solution in nitro-muriatic acid, after it is largely diluted with water. The precipitate must be cautiously roasted in a porcelain test, to burn away the large quantity of sulphur which is deposited in consequence of the conversion of the peroxyde of iron into the protoxyde. If nothing remains upon the test, none of these metals is present. If a residuum be obtained, it must be dissolved in nitro-muriatic acid, and subjected to examination. But, in fact, carbon, sulphur, phosphorus, silicon, and manganese, are the chief contaminators of iron.

Chloride of silver affords the means of determining the proportion of carbon contained in iron, and of ascertaining the state in which that substance exists in the metal. Fused

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chloride of a pale yellow color must be employed. The operation is to be performed in close vessels, with the addition of a great deal of water, and a few drops of muriatic acid. The carbonaceous residuum is occasionally slightly acted upon. We may judge of this circumstance by the gases disengaged, as well as by the appearance of the charcoal.

Ductile iron and soft steel, as well as white cast-iron which has been rendered gray by roasting, when decomposed by chloride of silver, afford a blackish-brown unmagnetic charcoal, and a plumbaginous substance perfectly similar to what is extracted from the same kinds of iron, by solution in acids. A portion of this plumbago is also converted into charcoal of a blackish brown color, by the action of the chloride. Hence this agent does not afford the means of obtaining what has been called the poly-carburet, till it has produced a previous decomposition. But we obtain it, in this manner, purer and in greater quantity than we could by dissolving the metal in the acids. The only subject of regret is, that we possess no good criterion for judging of the progress of this analytical operation.

Gray cast iron leaves, besides the poly-carburet, a residuum of plumbago, and carbon which was not chemically combined with the iron; while tempered steel and white cast iron afford merely a blackish brown charcoal; but the operation is extremely slow with the latter two bodies, because a layer of charcoal forms upon the surface, which obstructs their oxydizement. For this reason the white cast iron ought to be previously changed into gray by fusion in a crucible lined with charcoal, before being subjected to the chloride of silver; if this process be employed for tempered steel, the combined carbon becomes merely a poly-carburet. It would not be possible to operate upon more than 15 grains, which require from 60 to 80 times that quantity of the chloride, and a period of 15 days for the experiment.

The residuum, which is separable from the silver only by mechanical means, should be dried a long time at the heat of boiling water. It contains almost always iron and silica. After its weight is ascertained, it is to be burned in a crucible of platinum till the ashes no longer change their color, and are not attractable by the magnet. The difference between the weights of the dried and calcined residuum is the weight of the charcoal. The oxyde of iron is afterwards separated from the silica by muriatic acid.

In operating upon gray cast iron, we should ascertain separately the proportion of graphite or plumbago, and that of the combined charcoal. To determine the former, we dissolve a second quantity of the cast iron in nitric acid, with a little muriatic; the residuum, which is graphite, is separated from the silica and the combined carbon by the action of caustic potash. After being washed and dried, it must be weighed. The weight of the graphite obtained being deducted from the quantity of carbon resulting from the decomposition effected by the chloride of silver, the remainder is the amount of the chemically combined carbon.

By employing muriatic acid, we could dissipate at once the combined carbon; but this method would be inexact, because the hydrogen disengaged would carry off a portion of the graphite.

According to Karsten, Mushet's table of the quantities of carbon contained in different steels and cast irons is altogether erroneous. It gives no explanation why, with equal proportions of charcoal, cast iron constitutes at one time a gray, soft, granular metal, and at another, a white, hard, brittle metal in lamellar facets. The incorrectness of Mushet's statement becomes most manifest when we see the white lamellar cast iron melted in a crucible lined with charcoal, take no increase of weight, while the gray cast iron treated in the same way becomes considerably heavier.

Analysis has never detected a trace of carbon *unaltered* or of graphite in white cast iron, if it did not proceed from small quantities of the gray mixed with it; while perfect gray cast iron affords always a much smaller quantity of carbon altered by combination, and a much greater quantity of graphite. Neither kind of cast iron, however, betrays the presence of any oxygen. Steel affords merely altered carbon, without graphite; the same thing holds true of malleable iron; while the iron obtained by fusion with 25 per cent. of scales of iron contains no carbon at all.

The graphite of cast iron is obtained in scales of a metallic aspect, whereas the combined carbon is obtained in a fine powder. When the white cast iron has been roasted, and become gray, and is as malleable as the softest gray cast iron, it still affords no graphite as the latter does, though in appearance both are alike. Yet in their properties they are still essentially dissimilar.

With 4½ per cent. of carbon, the white cast iron preserves its lamellar texture; but with less carbon, it becomes granular and of a gray color, growing paler as the dose of carbon is diminished, while the metal, after passing through an indefinite number of gradations, becomes steely cast iron, very hard steel, soft steel, and steely wrought iron.

The steels of the forge and the cast steels examined by Karsten, afforded him from

2·3 to 1¼ per cent. of carbon; in the steel of cementation (blistered steel), he never found above 1⅜ of carbon. Some wrought irons which ought to contain no charcoal, hold as much as ½ per cent. and they then approach to steel in nature. The softest and purest irons contain still 0·2 per cent. of carbon.

The quantity of graphite which gray cast-iron contains, varies, according to Karsten's experiments, from 2·57 to 3·75 per cent.; but it contains, besides, some carbon in a state of alteration. The total contents in carbon varied from 3·15 to 4·65 per cent. When the congelation of melted iron is very slow, the carbon separates, probably in consequence of its crystallizing force, so as to form a gray cast-iron replete with plumbago. If the gray do not contain more charcoal than the white from which it has been formed, and if it contain the charcoal in the state of mechanical mixture, then it can have little or none in a state of combination, even much less than what some steels contain. Hence we can account for some of its peculiarities in reference to white cast-iron; such as its granular texture, its moderate hardness, the length of time it requires to receive annealing colors, the modifications it experiences by contact of air at elevated temperatures, the high degree of heat requisite to fuse it, its liquidity, and finally its tendency to rust by porosity, much faster than the white cast-iron.

We thus see that carbon may combine with iron in several manners; that the gray cast-iron is a mixture of steely iron and plumbago; that the white, rendered gray and soft by roasting, is a compound of steely iron and a carburet of iron, in which the carbon predominates; and that untempered steel is in the same predicament.

For the following analyses of cast-irons, we are indebted to MM. Gay Lussac and Wilson.

TABLE.—In 100 parts.

Cast-iron.		Iron.	Carbon.	Silica.	Phosphorus.	Manganese.	Remarks.
White cast from Siegen		94·338	2·690	0·230	0·162	2·590	By wood charcoal.
Do.	Coblentz -	94·654	2·441	0·230	0·185	2·490	do.
Do.	a. d. Champ	96·133	2·324	0·840	0·703	a trace	do.
Do.	Isère - -	94·687	2·636	0·260	0·280	2·137	do.
Gray	Nivernais -	95·673	2·254	1·030	1·043	a trace	do.
Do.	Berry - -	95·573	2·319	1·920	0·188	do.	Mixt'e of coke & do.
Do.	a. d. Champ	95·971	2·100	1·060	0·869	do.	Charcoal.
Do.	Creusot -	93·385	2·021	3·490	0·604	do.	Coke.
Do.	a. d. Franche Comté -	95·689	2·800	1·160	0·351	do.	do.
Do.	Wales - -	94·842	1·666	3·000	0·492	do.	do.
Do.	Do. - ↲ -	95·310	2·550	1·200	0·440	do.	do.
Do.	Do. - - -	95·150	2·450	1·620	0·780	do.	do.

Karsten has given the following results as to carbon, in 100 parts of gray cast-iron.

Gray cast-iron.	Combined carbon.	Free carbon.	Total. carbon.	Remarks.
Siegen, from brown iron stone -	0·89	3·71	4·60	By wood charcoal.
Siegen (Widderstein), from brown and sparry iron - - - - -	1·03	3·62	4·65	do.
Malapane, from spherosiderite -	0·75	3·15	3·90	do.
Königshütte, from brown ore -	0·58	2·57	3·15	coke.
Do. at a lower smelting heat - -	0·95	2·70	3·65	do.

Fig. 607 represents in section, and fig. 606 in plan, the famous cupola furnace for casting iron employed at the Royal Foundry in Berlin. It rests upon a foundation a, from 18 to 24 inches high, which supports the basement plate of cast-iron, furnished with ledges, for binding the lower ends of the upright side plates or cylinder, e. Near the mouth there is a top-plate d, made in several pieces, which serves to bind the sides at their upper end, as also to cover in the walls of the shaft. These plates are most readily secured in their places by screws and bolts. Within this iron case, at a little distance from it, the proper furnace-shaft e is built with fire-bricks, and the space between this and the iron is filled up with ashes. The sole of the hearth f, over the basement-plate, is composed of a mixture of fire-clay and quartz-sand firmly beat down to the thickness of 6 or 8 inches, with a slight slope towards the discharge-hole for running off the metal. g

is the *form* or the tuyère (there are sometimes one on each side); *k* the nose pipe : the discharge aperture *i* is 12 inches wide and 15 inches high; across which the sole of the hearth is rammed down. During the melting operation, this opening is filled up with fire-clay; when it is completed, a small hole merely is pierced through it at the lowest point, for running off the liquid metal. The hollow shaft should be somewhat
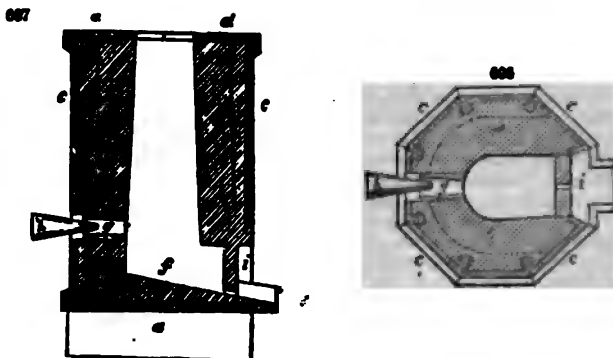
wider at bottom than at top. Its dimensions vary with the magnitude of the foundry. When 5 feet high, its width at the level of the tuyère or blast-hole may be from 20 to 22 inches. From 250 to 300 cubic feet of air per minute are required for the working of such a cupola. For running down 100 pounds of iron, after the furnace has been brought to its heat, 48 pounds of ordinary coke are used; but with the hot blast much less will suffice. The furnace requires feeding with alternate charges of coke and iron every 8 or 10 minutes. The waste of iron, by oxydization and slag, amounts in most foundries to fully 5 per cent. For carrying off the burnt air, a chimney-hood is commonly erected over the cupola. See FOUNDRY.

The double-arched air or wind-furnace used in the foundries of Staffordshire for melting cast-iron has been found advantageous in saving fuel, and preventing waste by slag. It requires fire-bricks of great size and the best composition.

The main central key-stone is constructed of large fire-bricks made on purpose ; against that key-stone the two arches press, having their abutments at the sides against the walls. The highest point of the roof is only 8 inches above the melted metal. The sole of the hearth is composed of a layer of sand 8 inches thick, resting upon a bed of iron or of brickwork. The edge of the fire-bridge is only 3 inches above the fluid iron.

In from 2 to 4 hours from 1 to 3 tons of metal may be founded in such a furnace, according to its size ; but it ought always to be heated to whiteness before the iron is introduced. 100 pounds of cast-iron require from 1 to 1½ cubic foot of coal to melt them. The waste varies from 5 to 9 per cent.

I shall conclude the subject of iron with a few miscellaneous observations and statistical tables. Previously to the discovery by Mr. Cort, in 1785, of the methods of puddling and rolling or shingling iron, this country imported 70,000 tons of this metal from Russia and Sweden : an enormous quantity for the time, if we consider that the cotton and other automatic manufactures, which now consume so vast a quantity of iron, were then in their infancy ; and that two years ago, the whole of our importation from these countries did not exceed 40,000 tons. From the following table of the prices of bar iron in successive years, we may infer the successive rates of improvement and economy, with slight vicissitudes.

Years.	Per Ton.				Years.	Per Ton.			
	£	s.	£	s.		£	s.	£	s.
1824	9	0	to 10	0	1830	5	5	— 6	0
1825	10	0	— 14	0	1831	5	5	— 5	10
1826	8	10	— 10	0	1832	5	0	— 5	10
1827	8	0	— 9	0	1833	5	10	— 6	0
1828	7	10	— 8	0	1834	6	0	— 6	10
1829	5	10	— 7	0	1835	5	10	— 7	0

I have been informed upon good authority that the total production of iron in Great Britain, in the year 1836, was almost exactly ONE MILLION OF TONS !

The export of iron that year, in bars, rods, pigs, castings, wire, anchors, hoops, nails, and old iron, amounted to 189,390 tons; in unwrought steel to 3,014, and in cutlery, to 21,072; in whole to 213,478 : leaving apparently for internal consumption, 776,522 tons, from which however one tenth probably should be deducted for waste, in the conversion cf the bar iron. Hence 700,000 tons may be taken as the approximate quantity of iron made use of in the United Kingdom, in the year 1836.

The years 1835 and 1836 being those of the railway mania over the world, produced a considerable temporary rise in the price of bar iron; but as this increased demand caused the construction of a great many more smelting and refining furnaces, it has tended eventually to lower the prices; an effect also to be ascribed to the more general use of the hot blast.

The relative cost of making cast iron at Merthyr Tydvil in South Wales, and at Glasgow, was as follows, eight or nine years ago.

At Merthyr.

*.	Tons.	Cwts.	Qrs.								£	s.	d.
Raw mine at 10 per ton,	3	7	0	-	-	-	-	-	-	-	1	13	6
Coal at 6	2	16	0	-	-	-	-	-	-	-	0	16	6
Limestone	1	5	2	-	-	-	-	-	-	-	0	1	4
Other charges -	-	-	-	-	-	-	-	-	-	-	0	9	1
Total Cost -	-	-	-	-	-	-	-	-	-	-	3	0	5

At Glasgow.

	*.	d.	Tons.	Cwts.								£.	s.	d.
Raw mine at 4	6		3	10	-	-	-	-	-	-	-	0	16	3
Splint coal at 2	5		5	15	-	-	-	-	-	-	-	0	14	0
Limestone at 0	3		0	14	-	-	-	-	-	-	-	0	3	6
Coals for the engine	1		1	10	-	-	-	-	-	-	-	0	3	0
Other charges	-		-	-	-	-	-	-	-	-	-	1	1	0
Total cost -	'-		-	-	-	-	-	-	-	-	-	2	17	9

The cost is still nearly the same at Merthyr, but it has been greatly decreased at Glasgow.

The saving of fuel by the hot-blast is said to be in fact so great, that blowing cylinders, which were adequate merely to work three furnaces at the first period, were competent to work four furnaces at the last period. The saving of materials has moreover been accompanied by an increase of one fourth in the quantity of iron, in the same time; as a furnace which turned out only 60 tons a week with the cold blast, now turns out no less than 80 tons. That the iron so made is no worse, but probably better, when judiciously smelted, would appear from the following statement. A considerable order was not long since given to four iron-work companies in England, to supply pipes to one of the London water-companies. Three of these supplied pipes made from the cold-blast iron; the fourth, it is said, supplied pipes made with the hot-blast iron. On subjecting these several sets of pipes to the requisite trials by hydraulic pressure, the last lot was found to stand the proof far better than any of the former three.—That iron was made with raw coal.

I have been since told by eminent iron-masters of Merthyr, that this statement stands in need of confirmation, or is probably altogether apocryphal, and that as they find the hot-blast weakens the iron, they will not adopt it.

Between the cast irons made in different parts of Great Britain, there are characteristic differences. The Staffordshire metal runs remarkably fluid, and makes fine sharp castings. The Welsh is strong, less fluent, but produces bar iron of superior quality. The Derbyshire iron also forms excellent castings, and may be worked with care into very good bar iron. The Scotch iron is very valuable for casting into hollow wares, as it affords a beautiful smooth skin from the moulds, so remarkable in the castings of the Carron company, in Stirlingshire, and of the Phœnix foundry, at Glasgow. The Shropshire iron resembles the Staffordshire in its good qualities.

The average quantity of fine metal obtainable from the forge-pigs at Merthyr Tydvil, from the finery furnace, is one ton for 22¼ cwts. of cast iron, with a consumption of about 9¼ cwts. of coal per ton.

Estimate from Neath Abbey Works.—continued.

16. Pieces of iron for a small forge, with two fires, two bellows, two anvils, iron
    tools faced with steel, and common iron tools, &c.   -   -   -   £100
17. Eight tons of cast-iron pieces, and wrought-iron pieces for 14 puddling fur-
    naces   -   -   -   -   -   -   -   -   983
18. Seven tons of cast-iron pieces, and wrought-iron for 4 re-heating furnaces   252
19. Tools for the puddlers and other workmen -   -   -   -   -   15
20. Iron mountings for two cranes, partly made of wood   -   -   -   50

    Total cost of machines and pieces of iron   -   -   -   -   -   £8165

To the above, the cost of the steam engine house is to be added, that of another forge
hammer, and incidental expenses.

In Staffordshire, the following estimate has been given :

A steam engine of 60-horse power   -   -   -   -   -   -   2016
Rolls, with the iron work of the furnaces, &c., to make 120 tons of bar iron
    weekly   -   -   -   -   -   -   -   -   -   2572

    £4588

    The Neath Abbey estimate is greater, but that company has a high character for making
substantial, well-finished machinery.

    Bar iron, made entirely from ore without admixture of cinder, or vitrified oxyde, is
always reckoned worth 10s. a ton more than the average iron in the market, which is
frequently made by smelting 25 per cent. of cinder with 75 of ore or *mine*, as it is called.

Importation of iron in bars or unwrought, for home consumption; and amount of duty, in

1836.	1837.	1836.	1837
18,978 tons 18 cwts.	13,470 tons 4 cwts.	£28,450	£20,065

M. Virlet's Statistical Table of the produce of Iron in Europe.

	Quintals.
England (1827) - - - - - -	- 7,098,000
France (1834) - - - - - -	- 2,200,000
Russia (1834) - - - - - -	- 1,150,000
Austria (1829) - - - - - -	- 850,000
Sweden (1825) - - - - - -	- 850,000
Prussia - - - - - - -	- 800,000
The Hartz Mountains - - - - -	- 600,000
Holland and Belgium - - - - -	- 600,000
Elba and Italy - - - - - -	- 280,000
Piedmont - - - - - -	- 200,000
Spain - - - - - -	- 180,000
Norway - - - - - -	- 150,000
Denmark - - - - - -	- 135,000
Bavaria - - - - - -	- 130,000
Saxony - - - - - -	- 80,000
Poland - - - - - -	- 75,000
Switzerland - - - - -	- 30,000
Savoy - - - - - -	- 25,000
Total - - - - - -	- 13,433,000 (equal to about 672,000 tons).

For additional statistics of iron, see PITCOAL, at the end.

    Bronzing of polished iron.—The barrels of fowling-pieces and rifles are occasionally
bronzed and varnished, to relieve the eye of the sportsman from the glare of a polished
metal, and to protect the surface from rusting. The liquid used for browning the barrels
is made by mixing nitric acid of specific gravity 1·2, with its own weight of spirit of nitric
ether, of alcohol, and tincture of muriate of iron ; and adding to that mixture a quantity
of sulphate of copper equal in weight to the nitric acid and ethereous spirit taken together.
The sulphate must be dissolved in water before being added ; and the whole being diluted
with about 10 times its weight of water, is to be bottled up for use. This liquid must be
applied by friction with a rag to the clear barrel, which must then be rubbed with a hard
brush ; processes to be alternated two or three times. The barrel should be afterwards
dipped in boiling water, rendered feebly alkaline with carbonate of potash or soda, well
dried, burnished, and heated slightly for receiving several coats of tin-smith's lacker,
consisting of a solution of shellac in alcohol, colored with dragon's blood.

    ISINGLASS, or Fish-glue, called in Latin *ichthyocolla*, is a whitish, dry, tough, semi-

transparent substance, twisted into different shapes, often in the form of a lyre, and consisting of membranes rolled together. Good isinglass is unchangeable in the air, has a leathery aspect, and a mawkish taste nearly insipid; when steeped in cold water, it swells, softens, and separates in membranous laminæ. At the boiling heat it dissolves in water, and the solution, on cooling, forms a white jelly, which is semi-transparent, soluble in weak acids, but is precipitated from them by alkalis. It is gelatine nearly pure; and if not brittle, like other glue, this depends on its fibrous and elastic texture. The whitest and finest is preferred in commerce. Isinglass is prepared from the air-bladders of sturgeons, and especially the great sturgeon, the *accipenser huso;* which is fished on the shores of the Caspian sea, and in the rivers flowing into it, for the sake chiefly of its swim bladder.

The preparation of isinglass in this part of Russia, and particularly at Astracan, consists in steeping these bladders in water, removing carefully their external coat, and the blood which often covers them, putting them in a hempen bag, squeezing them, softening them between the hands, and twisting them into small cylinders, which are afterwards bent into the shape of a lyre. They are ready for the market immediately after being dried in the sun, and whitened with the fumes of burning sulphur.

In some districts of Moldavia, another process is followed. The skin, the stomach, the intestines, and the swim bladder of the sturgeon are cut in small pieces, steeped in cold water, and then gently boiled. The jelly thus obtained is spread in thin layers to dry, when it assumes the appearance of parchment. This being softened in a little water, then rolled into cylinders, or extended into plates, constitutes an inferior article.

The swim bladder of the cod and many other fishes also furnishes a species of isinglass, but it is much more membranous, and less soluble, than that of the sturgeon.

The properties of isinglass are the same as those of gelatine or pure glue; and its uses are very numerous. It is employed in considerable quantities to clarify ale, wine, liqueurs, and coffee. As an article of food to the luxurious in the preparation of creams and jellies, it is in great request. Four parts of it convert 100 of water into a tremulous jelly, which is employed to enrich many soups and sauces. It is used along with gum as a dressing to give lustre to ribands and other silk articles. The makers of artificial pearls employ it to fix the *essence d'Orient* on the glass globules which form these pearls, and the Turks set their precious stones or jewellery by means of isinglass dissolved in alcohol along with gum ammoniac; a combination which is also employed in this country to join broken pieces of China and glass, under the name of diamond cement. That setting preserves its transparency after it solidifies, if it be well made.

It is by covering taffety or thin silk with a coat of isinglass that court plaster is made. A solution of isinglass colored with carmine forms an excellent injection liquor to the anatomist. M. Kochen has made another pretty application of isinglass. He plunges into a limpid solution of it, made by means of a water bath, sheets of wire gauze set in window or lamp frames, which, when cold, have the appearance of glass, and answer instead of it for shades and other purposes. If one dip be not sufficient to make a proper transparent plate of isinglass, several may be given in succession, allowing each film to harden in the interval between the dips. The outer surface should be varnished to protect it from damp air. These panes of gelatine are now generally used for lamps instead of horn, in the maritime arsenals of France.

Isinglass imported for home consumption, and duties paid, in

1835.	1836.	1835.	1836.
1,814 cwts.	1,735 cwts.	£4,290	£4,125

ISLAND MOSS (*Lichen d'Islande,* Fr.; *Flechte Isl.,* Germ.) is a lichen, the *Cetraria islandica,* which contains a substance soluble in hot water, but forming a jelly when it cools, styled *lichenine* by M. Guerin. Lichenine has a yellowish tint in the dry state, is transparent in thin plates, insipid, inodorous, and difficult to pulverize. Cold water makes it swell, but does not dissolve it. It is precipitated in white flocks by alcohol and ether. Iodine tinges it of a brownish-green. Sulphuric acid converts it into sugar; and the nitric into oxalic acid. Lichenine is prepared by extracting first of all from the plant a bitter coloring matter, by digesting 1 pound of it in 16 pounds of cold water, containing 1 ounce of pearlash; then draining the lichen, edulcorating with cold water, and boiling it in 9 pounds of boiling water till 3 pounds be evaporated. The jelly which forms, upon cooling the filtered solution, is dark colored, but, being dried and redissolved in hot water, it becomes clear and colorless. Lichenine consists of 39·33 carbon, 7·24 hydrogen, and 55·43 oxygen. With potash, lime, oxyde of lead, and tincture of galls, the habitudes of lichenine and starch are the same. The mucilage of island moss is preferred in Germany to common paste for dressing the warp of webs in the loom, because it remains soft, from its hygrometric quality. It is also mixed with .the pulp for sizing paper in the vat.

IVORY (*Ivoire,* Fr.; *Elfenbein,* Germ.) is the osseous matter of the tusks and

teeth of the elephant, the hippopotamus, or morse, wild boar, several species of phoca, as well as the horn or tooth of the narwhal. Ivory is a white, fine-grained, dense substance, of considerable elasticity, in thin plates, and more transparent than paper of equal thickness. The outside of the tusk is covered by the cortical part, which is softer and less compact than the interior substance, with the exception of the brown plate that sometimes lines the interior cavity. The hardest, toughest, whitest, and most translucent ivory, has the preference in the market; and the tusks of the sea-horse are considered to afford the best. In these, a rough glassy enamel covers the cortical part, of such hardness, as to strike sparks with steel. The horn of the narwhal is sometimes ten feet long, and consists of an ivory of the finest description, as hard as that of the elephant, and susceptible of a better polish; but it is not in general so much esteemed as the latter.

Ivory has the same constituents as the teeth of animals, three fourths being phosphate, with a little carbonate of lime; one fourth cartilage. See Bones.

It is extensively employed by miniature painters for their tablets; by turners, in making numberless useful and ornamental objects; by cutlers, for the handles of knives and forks; by comb-makers; as also by philosophical instrument makers, for constructing the scales of thermometers, &c. The ivory of the sea-horse is preferred by dentists for making artificial teeth; that of the East India elephant is better than of the African. When it shows cracks or fissures in its substance, and when a splinter broken off has a dull aspect, it is reckoned of inferior value. Ivory is distinguishable from bone by its peculiar semi-transparent rhombohedral net-work, which may be readily seen in slips of ivory cut transversely.

Ivory is very apt to take a yellow-brown tint by exposure to air. It may be whitened or bleached, by rubbing it first with pounded pumice-stone and water, then placing it moist under a glass shade luted to the sole at the bottom, and exposing it to sunshine. The sunbeams without the shade would be apt to occasion fissures in the ivory The moist rubbing and exposure may be repeated several times.

For etching ivory, a ground made by the following recipe is to be applied to the polished surface:—Take of pure white wax, and transparent tears of mastic, each one ounce; asphalt, half an ounce. The mastic and asphalt having been separately reduced to fine powder, and the wax being melted in an earthenware vessel over the fire, the mastic is to be first slowly strewed in and dissolved by stirring; and then the asphalt in like manner. This compound is to be poured out into lukewarm water, well kneaded, as it cools, by the hand, into rolls or balls about one inch in diameter. These should be kept wrapped round with taffety. If white rosin be substituted for the mastic, a cheaper composition will be obtained, which answers nearly as well; 2 oz. asphalt, 1 oz. rosin, ½ oz. white wax, being good proportions. Callot's etching ground for copper plates, is made by dissolving with heat 4 oz. of mastic in 4 oz. of very fine linseed oil; filtering the varnish through a rag, and bottling it for use.

Either of the two first grounds being applied to the ivory, the figured design is to be traced through it in the usual way, a ledge of wax is to be applied, and the surface is to be then covered with strong sulphuric acid. The effect comes better out with the aid of a little heat; and by replacing the acid, as it becomes dilute by absorption of moisture, with concentrated oil of vitriol. Simple wax may be employed instead of the copperplate engraver's ground; and strong muriatic acid instead of sulphuric. If an acid solution of silver or gold be used for etching, the design will become purple or black, on exposure to sunshine. The wax may be washed away with oil of turpentine. Acid nitrate of silver affords the easiest means of tracing permanent black lines upon ivory.

Ivory may be dyed by using the following prescriptions:—

1. *Black dye.*—If the ivory be laid for several hours in a dilute solution of neutral nitrate of pure silver, with access of light, it will assume a black color, having a slightly green cast. A still finer and deeper black may be obtained by boiling the ivory for some time in a strained decoction of logwood, and then steeping it in a solution of red sulphate or red acetate of iron.

2. *Blue dye.*—When ivory is kept immersed for a longer or shorter time in a dilute solution of sulphate of indigo (partly saturated with potash), it assumes a blue tint of greater or less intensity.

3. *Green dye.*—This is given by dipping blued ivory for a little while in solution of nitro-muriate of tin, and then in a hot decoction of fustic.

4. *Yellow dye* is given by impregnating the ivory first with the above tin mordant, and then digesting it with heat in a strained decoction of fustic. The color passes into orange, if some Brazil wood has been mixed with the fustic. A very fine unchangeable yellow may be communicated to ivory by steeping it 18 or 24 hours in a strong solution of the neutral chromate of potash, and then plunging it for some time in a boiling hot solution of acetate of lead.

5. *Red dye*—may be given by imbuing the ivory first with the tin mordant, then plunging it in a bath of Brazil wood, cochineal, or a mixture of the two. Lac-dye may be used with still more advantage, to produce a scarlet tint. If the scarlet ivory be plunged for a little in a solution of potash, it will become cherry red.

6. *Violet dye*—is given in the logwood bath to ivory previously mordanted for a short time with solution of tin. When the bath becomes exhausted, it imparts a lilach hue. Violet ivory is changed to purple-red by steeping it a little while in water containing a few drops of nitro-muriatic acid.

With regard to dyeing ivory, it may in general be observed, that the colors penetrate better before the surface is polished than afterwards. Should any dark spots appear, they may be cleared up by rubbing them with chalk; after which the ivory should be dyed once more to produce perfect uniformity of shade. On taking it out of the boiling hot dye bath, it ought to be immediately plunged into cold water, to prevent the chance of fissures being caused by the heat.

If the borings and chips of the ivory-turner, called ivory dust, be boiled in water, a kind of fine size is obtained.

The importation of elephants' teeth for home consumption was, in 1834, 4,282 cwts.; in 1835, 3,698; and in 1836, 4,584 cwts.; duty, 1*l.* per cwt.

IVORY BLACK (*Noir d'ivoire*, Fr.; *Kohle von Elfenbein*, Germ.) is prepared from ivory dust, by calcination, in the very same way as is described under BONE BLACK.

The calcined matter, being ground and levigated on a porphyry slab, affords a beautiful velvety black, much used in copperplate printing. Ivory black may be prepared upon the small scale, by a well regulated ignition of the ivory dust in a covered crucible.

K.

KALI. The Arabs gave this name to an annual plant which grows near the sea-shore; now known under the name of *salsola soda*, and from whose ashes they extracted a substance, which they called *alkali*, for making soap. The term *kali* is used by German chemists to denote caustic potash; and *kalium*, its metallic basis; instead of our *potassa* and *potassium*, of preposterous pedigree, being derived from the words *pot ashes*, that is, ashes prepared in a pot.

KAOLIN (*Terre à porcelaine*, Fr.; *Porzellanerde*, Germ.) is the name given by the Chinese to the fine white clay with which they fabricate the biscuit of their porcelains. See CLAY. Berthier's analyses of two porcelain earths are as follows:—

Analyses.	From Passau.	From Saint Yriex.
Silica	45·06	46·8
Alumina . . .	32·00	37·3
Lime	0·74	—
Oxyde of iron . .	0·90	—
Potass	—	2·5
Water . . .	18·0	13·0
	96·7	99·6

KARABE', a name of amber, of Arabic origin, in use upon the Continent.

KELP (*Varec*, Fr.; *Wareck*, Germ.) is the crude alkaline matter produced by inciner-ating various species of fuci, or *sea-weed*. They are cut with sickles from the rocks in the summer season, dried and then burned, with much stirring of the pasty ash. I have analyzed many specimens of kelp, and found the quantity of soluble matter in 100 parts of the best to be from 53 to 62, while the insoluble was from 47 to 38. The soluble consisted of—

Sulphate of Soda -	-	-	-	-	-	8·0	19·0
Soda in carbonate and sulphuret -		-	-	-		8·5	5·5
Muriate of soda and potash	-	-	-	-		36·5	37·5
						53·0	62·0

The insoluble matter consisted of—

Carbonate of lime	-	-	-	-	-	24·0	10·0
Silica -	-	-	-	-	-	-	8·0	0·0
Alumina tinged with iron oxyde	-	-	-	-	9·0	10·0
Sulphate of lime	-	-	-	-	-	-	0·0	9·5
Sulphur and loss	-	-	-	-	-	-	6·0	8·5
						100·0	100·0

The first of these specimens was from Heisker, the second from Rona, both in the isle of Skye, upon the property of Lord Macdonald. From these, and many other analyses which I have made, it appears that kelp is a substance of very variable composition, and hence it was very apt to produce anomalous results, when employed as the chief alkaline flux of crown glass, which it was for a very long period. The *fucus vesiculosus* and *fucus nodosus* are reckoned to afford the best kelp by incineration; but all the species yield a better product when they are of two or three years growth, than when cut younger. The *varec*, made on the shores of Normandy, contains almost no carbonate of soda, but much sulphate of soda and potash, some hyposulphate of potash, chloride of sodium, iodide of potassium, and chloride of potassium; the average composition of the soluble salts being, according to M. Gay Lussac, 56 of chloride of sodium, 25 of chloride of potassium, and a little sulphate of potash. The very low price at which soda ash, the dry crude carbonate from the decomposition of sea salt, is now sold, has nearly superseded the use of kelp, and rendered its manufacture utterly unprofitable—a great misfortune to the Highlands and Islands of Scotland.

KERMES. There are two substances so called, of totally different natures. *Kermes mineral* is merely a factitious sulphuret of antimony in a state of impalpable comminution, prepared in the moist way. Its minute examination belongs to pharmaceutical chemistry. It may be obtained perfectly pure, by diluting the proto-chloride of antimony with solution of tartaric acid, and precipitating the metal with sulphureted hydrogen; or by exposing the finely levigated native sulphuret to a boiling solution of carbonate of potash for some time, and filtering the liquor while boiling hot. The kermes falls down in a brown-red powder, as the liquor cools.

Kermes-grains, alkermes, are the dried bodies of the female insects of the species *coccus ilicis*, which lives upon the leaves of the *quercus ilex* (prickly oak). The word *kermes* is Arabic, signifies little worm. In the middle ages, this dye stuff was therefore called *vermiculus* in Latin, and *vermilion* in French. It is curious to consider how the name *vermilion* has been since transferred to red sulphuret of mercury.

Kermes has been known in the East since the days of Moses; it has been employed from time immemorial in India to dye silk; and was used also by the ancient Greek and Roman dyers. Pliny speaks of it under the name of *coccigranum*, and says that there grew upon the oak in Africa, Sicily, &c. a small excrescence like a bud, called *cusculium*; that the Spaniards paid with these grains, half of their tribute to the Romans; that those produced in Sicily were the worst; that they served to dye purple; and that those from the neighborhood of Emerita in Lusitania (Portugal) were the best.

In Germany, during the ninth, twelfth, thirteenth, and fourteenth centuries, the rural serfs were bound to deliver annually to the convents, a certain quantity of kermes, the *coccus polonicus*, among the other products of husbandry. It was collected from the trees upon Saint John's day, between eleven o'clock and noon, with religious ceremonies, and was therefore called *Johannisblut* (Saint John's blood), as also German cochineal. At the above period, a great deal of the German kermes was consumed in Venice, for dyeing the scarlet to which that city gives its name. After the discovery of America, cochineal having been introduced, began to supersede kermes for all brilliant red dyes.

The principal varieties of kermes are the *coccus quercus,* the *coccus polonicus,* the *coccus fragariæ,* and the *coccus uva ursi.*

The *coccus quercus* insect lives in the south of Europe upon the kermes oak. The female has no wings, is of the size of a small pea, of a brownish-red color, and is covered with a whitish dust. From the middle of May to the middle of June the eggs are collected, and exposed to the vapor of vinegar, to prevent their incubation. A portion of eggs is left upon the tree for the maintenance of the brood. In the department of the Bouches-du-Rhone, one half of the kermes crop is dried. It amounts annually to about 60 quintals or cwts., and is warehoused at Avignon.

The kermes of Poland, or *coccus polonicus,* is found upon the roots of the *scleranthus perennis* and the *scleranthus annuus,* in sandy soils of that country and the Ukraine. This species has the same properties as the preceding; one pound of it, according to Wolfe, being capable of dyeing 10 pounds of wool; but Hermstaedt could not obtain a fine color, although he employed 5 times as much of it as of cochineal. The Turks, Arme-

nians, and Cossacks, dye with kermes their morocco leather, cloth, silk, as well as the manes and tails of their horses.

The kermes called *coccus fragariæ*, is found principally in Siberia, upon the root of the common strawberry.

The *coccus uvæ ursi* is twice the size of the Polish kermes, and dyes with alum a fine red. It occurs in Russia.

Kermes is found not only upon the *lycopodium complanatum* in the Ukraine, but upon a great many other plants.

Good kermes is plump, of a deep red color, of an agreeable smell, and a rough and pungent taste. Its coloring matter is soluble in water and alcohol; it becomes yellowish or brownish with acids, and violet or crimson with alkalis. Sulphate of iron blackens it. With alum it dyes a blood-red; with copperas an agate gray; with copperas and tartar, a lively gray; with sulphate of copper and tartar, an olive green; with tartar and salt of tin, a lively cinnamon yellow; with more alum and tartar, a lilach; with sulphate of zinc and tartar, a violet. Scarlet and crimson dyed with kermes, were called *grain colors*; and they are reckoned to be more durable than those of cochineal, as is proved by the brilliancy of the old Brussels tapestry.

Hellot says that previous to dyeing in the kermes bath, he threw a handful of wool into it, in order to extract a blackish matter, which would have tarnished the color. The red caps for the Levant are dyed at Orleans with equal parts of kermes and madder; and occasionally with the addition of some Brazil wood.

Cochineal and lac-dye have now nearly superseded the use of kermes as a tinctorial substance, in England.

KILLAS is the name by which clay-slate is known among the Cornish miners.

KILN (*Four*, Fr.; *Ofen*, Germ.) is the name given to various forms of furnaces and stoves, by which an attempered heat may be applied to bodies; thus there are brick-kilns, hop-kilns, lime-kilns, malt-kins, and pottery-kilns. Hop and malt-kilns, being designed merely to expel the moisture of the vegetable matter, may be constructed in the same way. See BRICK, LIMESTONE, MALT, and POTTERY, for a description of their respective kilns.

KINIC ACID; a peculiar acid extracted by Vauquelin from cinchona.

KINO is an extractive matter obtained from the *nauclea gambir*, a shrub which grows at Baneoul and Sumatra, but principally in Prince of Wales' island. It is of a reddish-brown color, has a bitter styptic taste, and consists chiefly of tannin. It is used only as an astringent in medicine. Kino is often called a gum, but most improperly.

KIRSCHWASSER is an alcoholic liquor obtained by fermenting and distilling bruised cherries, called *kirschen* in German. The cherry usually employed in Switzerland and Germany is a kind of morello, which on maturation becomes black, and has a kernel very large in proportion to its pulp. When ripe, the fruit being made to fall by switching the trees, is gathered by children, thrown promiscuously, unripe, ripe, and rotten into tubs, and crushed either by hand, or with a wooden beater. The mashed materials are set to ferment, and whenever this process is complete, the whole is transferred to an old still covered with verdigris, and the spirit is run off in the rudest manner possible, by placing the pot over the common fire-place.

The fermented mash is usually mouldy before it is put into the alembic, the capital of which is luted on with a mixture of mud and dung. The liquor has accordingly, for the most part, a rank smell, and is most dangerous to health, not only from its own crude essential oil, but from the prussic acid, derived from the distillation of the cherry-stones.
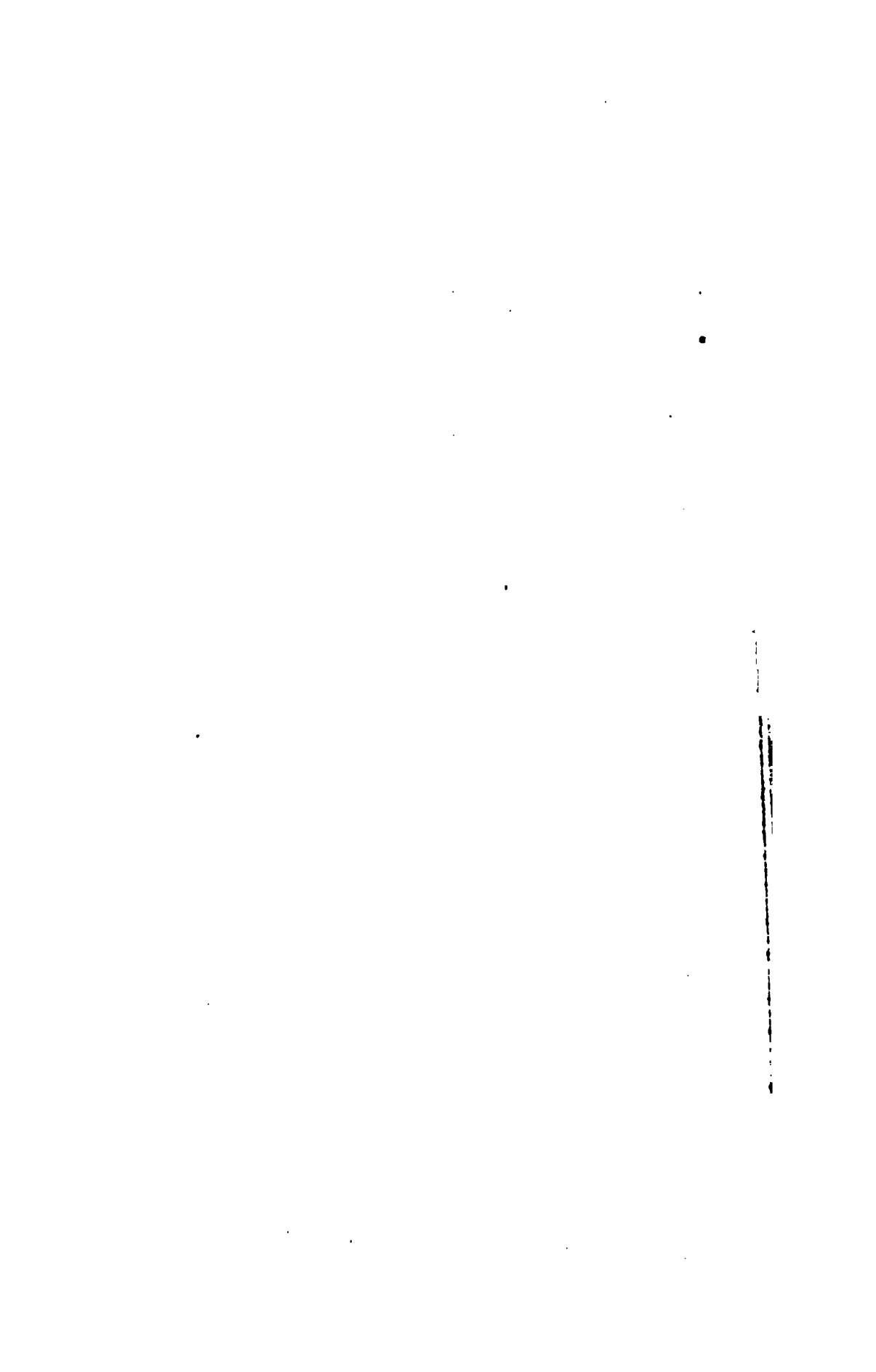
There is a superior kind of *kirschwasser* made in the Black Forest, prepared with fewer kernels, from choice fruit, properly pressed, fermented, and distilled.

KNOPPERN are excrescences produced by the puncture of an insect upon the flower-cups of several species of oak. They are compressed or flat, irregularly pointed, generally prickly and hard; brown when ripe. They abound in Styria, Croatia, Sclavonia, and Natolia; those from the latter country being the best. They contain a great deal of tannin, are much employed in Austria for tanning, and in Germany for dyeing fawn, gray, and black. Wool, with a mordant of sulphate of zinc, takes a grayish nankeen color. See GALLS.

KOUMISS is the name of a liquor which the Calmucs make by fermenting mare's milk, and from which they distil a favorite intoxicating spirit, called *rack* or *racky*. Cow's milk is said to produce only one third as much spirit, from its containing probably less saccharine matter.

The milk is kept in bottles made of hides, till it becomes sour, is shaken till it casts up its cream, and is then set aside in earthen vessels in a warm place to ferment, no yeast being required, though sometimes a little old koumiss is added. 21 pounds of milk put into the still afford 14 ounces of low wines, from which 6 ounces of pretty strong alcohol, of an unpleasant flavor, are obtained by rectification.